

B
827
B87



The date shows w

To renew this book copy the call no. and give it
to the librarian.

HOME USE RULES.

All Books subject to Recall.

Books not in use for instruction or research are returnable within 4 weeks.

Volumes of periodicals and of pamphlets are held in the library as much as possible. For special purposes they are given out for a limited time.

Borrowers should not use their library privileges for the benefit of other persons.

Students must return all books before leaving town. Officers should arrange for the return of books wanted during their absence from town.

Books needed by more than one person are held on the reserve list.

Books of special value and gift books, when the giver wishes it, are not allowed to circulate.

Readers are asked to report all cases of books marked or mutilated.

Do not deface books by marks and writing.

Corne

Philos

A.271388

15 11 13



Radium and Materialism

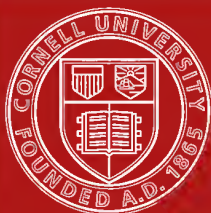
OR

PHYSICAL MONISM



BY
JAMES BROWN
Professor of Chemistry and Physics
William and Vashti College
Aledo, Illinois

1910
ALL RIGHTS RESERVED



Cornell University
Library

The original of this book is in
the Cornell University Library.

There are no known copyright restrictions in
the United States on the use of the text.

7295

D95

Radium and Materialism

OR

PHYSICAL MONISM



BY
JAMES BROWN
Professor of Chemistry and Physics
William and Vashti College
Aledo, Illinois

1910
ALL RIGHTS RESERVED

A.271358

PREFACE

The contents of these pages are the result of a few years of investigation and thought which the author has devoted to a consideration of the relation of natural science and theology. I have attempted to treat the subject in the only way which I think can be satisfactory to both sides. It has been my aim to take into account all the facts of science which have any bearing on the subject; to select those questions which bring science and theology together on common ground; then to show that there is no conflict between the facts of science and anything that is essential in theology.

The author claims for himself no great amount of originality in the treatment of the subject. He has attempted to select the best authorities available, to outline these briefly, to correlate them, and show what they contribute toward the development of the subject.

The authorities are indicated briefly in the foot notes. A complete list of authors and titles may be found in the bibliography at the end of the book.

CONTENTS

Chapter.	Page.
I. Inorganic Evolution	7
II. Monism of Physical Phenomena of Life	15
III. Materialistic "Psychic" Phenomena	32
IV. Fundamental Entities and Creation	44

RADIUM AND MATERIALISM OR PHYSICAL MONISM

CHAPTER I

INORGANIC EVOLUTION

From a very early period in the history of human thought, there has existed a well-defined and persistent attempt to simplify and unify all man's material and mental experiences, and to account for all as originating from some one fundamental reality. This philosophical tendency has received the name "Monism." To quote a recent writer: "The name 'Monism' should apply to any philosophic system which assumes and attempts to formulate the essential simplicity and oneness of all the apparent diversity of sensual impression and consciousness, any system which seeks to exhibit all the complexities of existence, both material and mental—the whole of phenomena, both objective and subjective—as modes of manifestation of one fundamental reality." (1). Thus Evolution is Monism as applied to animal and to vegetable life.

Among the earliest Monists we find the Alchemists. Their system was called Alchemy. The alchemists sought to discover some unifying principle which was supposed to contain "all the powers and potencies of life and whatever makes life worth living." (2) Possessed of this they believed they would be able to change or transmute any metal into gold, to cure all diseases, to attain perpetual youth, and the happiness which the knowledge of the supreme secret of nature could alone secure. The alchemist did not hope to create gold. God alone can create. He hoped only to produce gold from other substances. Lead purified, the thought, would give gold or silver. He believed that every substance contains undeveloped resources and potentialities. These he felt confident he could develop if only he could discover the one unifying principle. He never for a moment doubted its existence. "The alchemist's conception of an orderly, material universe was so intimately connected with his ideas of morality and religion, that to disprove the possibility of the" transmutation of the metals, "would be to remove not only the basis of his system of material things, but the foundations of his system of ethics also. To take away his belief in the possibility of changing other metals into gold would be to convert the alchemist into an atheist." (3) I mention this fact because of man's apparent tendency to establish a necessary re-

(1) Lodge, page 6.

(2) Muir, page 32.

(3) Muir, page 47.

lationship between his religious dogmas and his theories of the material creation.

The unifying principle of the alchemists was not discovered. As investigation continued the attempt to discover it was abandoned or took on different forms. The various branches of scientific and philosophic inquiry developed along lines apparently more or less divergent. But continually and persistently whether we view the separate sciences by themselves or their inter-relations, we find more or less definite principles brought forward as attempts to unify man's material and psychical activities. Monism seems to be man's natural tendency.

We find now existent three distinct brands of monistic theory:

According to the first "everything is an aspect of some unknown absolute reality * * which is far beyond our apprehension or conception." (1). This system includes "such utterly different universe conceptions as that of Herbert Spencer and that of Spinoza." (2)

The second system asserts that the unifying reality is consciousness, "and that the material world has only the relaity appropriate to a consistent set of ideas." (2) This system might be called Psychic Monism.

The third system of monism considers the all-embracing reality to be "matter," "energy" or "substance." Mind, thought, and consciousness are regarded as by-products, or developments of this reality. This system is called Physical Monism, or Materialism. To a consideration of the present status of this system, we will devote this paper.

With the passing of Alchemy the idea of the transmutation of the metals was gradually discarded and in its place was developed the modern theory of elements. Let us consider briefly the nature of this concept.

If I heat dry cane sugar at a moderately high temperature I will obtain a black residue. This residue is carbon. If I condense the fumes given off by the sugar I will find them to be water. If then I pass an electric current through the pure water obtained in this or in any other way, it will be decomposed into two invisible gases, hydrogen and oxygen. Now let us try to decompose the hydrogen, and oxygen thus obtained and the carbon which constitutes the residue when sugar is burned. Try as we may we will not succeed in producing any visible decomposition of any one of these three substances into simpler substances. They can be combined in various proportions to produce thousands of more complex substances called compounds. They can not by ordinary means be broken up into simpler substances. Substances such as these which cannot be made from or broken up into simpler substances are called elements. There are between seventy and eighty such elements known. They include besides the carbon, hydrogen, and oxygen just discussed, all simple metals, and many non-metallic substances, such as sulphur and iodine. These elements unite to give all the objects of material existence, but cannot, it

(1) Lodge, page 6.

(2) Lodge, page 7.

was formerly, and perhaps is still, supposed, be made from simpler substances.

Investigation of the different elements has shown that there is for each a minimum weight of it which combines with other elements to form compounds. It was formerly supposed that this minimum weight corresponded to the smallest particle of the element which could exist. This minimum weight was called the atom. Each element consists of atoms, and it was formerly supposed that the atom of any element was entirely different from the atom of every other element. Thus science had asserted a unit for each element, but had found no unifying or monistic material correlating all the atoms and elements. There was no physical monism. Elements and atoms suggesting no common origin were the concepts of the older physical science.

To the elements was ascribed the property of ultimate simplicity, to the atoms that of indivisibility. Scientists were, however, careful to define an element as a substance which has never been broken up into simpler substances; no one cared to assume the responsibility of asserting that they cannot be broken up. In fact from an early date attempts were made to discover some common material from which all the elements might be considered as developed.

For this tendency two reasons may be mentioned. The first was man's monistic tendency which we find ever prevalent. The second was the fact that all the elements can be subdivided into nine groups, such that the elements in the same group show closely similar properties and gradations, both physical and chemical. Thus phosphorus and arsenic resemble each other very closely; these two elements belong to the same group or family. The silver salts of chlorine, bromine and iodine show striking resemblances, so that all three are used in photography. Chlorine, bromine and iodine belong to the same group or family of the elements.

Why do the elements display these family resemblances. "Throughout all biological science family relationship is taken indubitably to mean common origin. Evolution is based on this assumption. Whenever the biologist finds a series of organisms, vegetable or animal, betraying in their structure manifold likeness of form, he says at once. "These organisms have had a common ancestry; they have been evolved, all of them, from some one simpler form. Now it is this very form of argument that takes us inevitably to the conclusion that the atomic families," or families of the elements, "since they show family relationships as sharply defined as any to be found in biology, are of common origin and descent, and that the atoms, as we know them, are the product of an evolution—an inorganic evolution." (1) "We accept the organic evolution. It seems equally reasonable to accept the inorganic evolution. The organic evolution, required millions, the inorganic probably billions of years."

But, one may say, have we any simple form from which the elements may reasonably be supposed to be derived. In biology we have simple

(1) Duncan, page 41.

cells which by increasing growth and complexity give higher forms. Have we among the elements such a simple form? Until recent years such an argument would have silenced the advocate of inorganic evolution. With the discovery of radium and other elements resembling it, the inorganic evolutionist has a stock of experimental evidence and observed facts as convincing as any the organic evolutionist can offer, and they stand without challenge.

What then are the peculiar properties of radium, and other radio-active elements, and what bearing have these properties on inorganic evolution? Radium is an element. It forms compounds like metallic elements. It has a characteristic spectrum as have all elements. In one respect, however, radium is unique. It emits heat and light spontaneously and incessantly. If we look at a piece of iron under ordinary atmospheric conditions we will see no evidence of instantaneous activity. Such is not the case with radium. Investigation has shown that radium disintegrates spontaneously emitting enormous quantities of heat and light, and minute particles possessing about 1-1800 the weight of the hydrogen atom. These particles are charged with negative electricity. They are called corpuscles, electrons, or Beta particles.

Radium seems then to involve us in a contradiction. We have called radium an element. We find it disintegrates and gives off a simpler substance, the electron. It was a concept of the old science to think of an element as a non-decomposable entity. Radium is decomposable. Let us recall, however, that an element was defined as a substance which had not been decomposed. No one would state that it could not be decomposed. Radium has shown that ultimate simplicity and indivisibility can no longer be regarded as necessary properties of an element and of an atom respectively.

But what has this to do with a common origin for all the elements? What common constituent is contained by all the elements, and what light does the decomposition of radium throw on this question? We will see. Besides radium three other elements, namely, Uranium, Thorium, and Actinium, the so-called "radio-active" elements, exhibit the property of disintegrating spontaneously at a rate easily detectable. Probably all elements possess the same property, though most of them in so slight a degree that it is not detected under ordinary circumstances. By artificial means we can hasten the decomposition of elements with production of electrons.

In short, the following sources of electrons have been proven by experiment: (1) Radium and the other three radio-active elements, namely Uranium, Thorium and Actinium; (2) burning gases; (3) electrical discharges in gases at low pressure; (4) X-rays; (5) metals on the impact of ultra-violet light; (6) glowing metals and carbon; (7) cathode rays; (8) metals and other bodies, especially alkali metals, when exposed to light. In fact any substance will give corpuscles more or less if subjected to proper conditions, heating being the most common method. There

is good reason to believe that electrons or corpuscles reach us from the sun. Corpuscles are found everywhere in minute quantities, in the air of cellars and caves, throughout the surface of the earth, and in the atmosphere.

These corpuscles or electrons show the same properties in all essential respects, regardless of the source. They all have a weight approximating 1-1800 that of the hydrogen atom; they carry a definite quantity of negative electricity. Corpuscles can detach themselves from one body, and attach to another. Bodies negatively charged have an excess of corpuscles, bodies positively charged a deficiency. To quote J. J. Thompson, a leading authority on this subject: "The corpuscle appears to form a part of all kinds of matter under the most diverse conditions. It seems natural, therefore, to regard it as one of the bricks of which atoms are built up." (1).

We have then in the corpuscle probably the unifying principle, the common simple material of which the atoms of all the elements are constituted in part or entirely. We have approached very near to the alchemist's dream of the transmutation of the metals and of the elements in general. All the radio-active elements give helium, another element, on decomposition. Radium gives probably lead, thorium bismuth and uranium radium as decomposition products, all of which are elements in the common acceptance of the term. Science has gone far toward fulfilling the prophetic words of Faraday nearly a century old: "To decompose the metals, to reform them, and to realize the once absurd notion of transmutation, are the problems now given to the chemist for solution." (2) With the entire fulfillment of this prophecy, which now seems not improbable, the monism of matter will be a fully demonstrated fact.

Before passing to the next division of our subject let us consider a few corollaries of the disintegration of elements and the formation of corpuscles. In this way we will see what a unifying or monistic principle science has revealed.

We know if we heat most compounds at the moderate temperature of the Bunsen flame, they are decomposed more or less completely into their constituent elements. Heated at still higher temperatures the decomposition becomes more complete. Along with this decomposition, corpuscles are liberated, though generally in small amounts. If the temperatures which man has at his disposal, not exceeding in general 3,500 to 4,000 degrees C., are able to accomplish this partial decomposition of elements, what may we expect of the temperatures, ranging as high as tens of thousands of degrees, which exist among the heavenly bodies? At temperatures sufficiently high we may reasonably expect total decomposition of the elements into atoms and corpuscles. Under such conditions no life, no tangible bodies such as we know them, could exist. Such a

(1) J. J. Thompson, page 11.

(2) Duncan, page 140.

space would be a chaos of corpuscles and atoms with little, or no tendency to cohere and produce large masses. As such a system cooled gradually the corpuscles would unite to form atoms, first the lightest atoms of the gaseous elements such as hydrogen, oxygen, and nitrogen. As cooling continued there would be formed the lightest solid, and liquid elements; and finally the heaviest solid elements including the metals. Progressive cooling would form compounds; then the compounds would adhere to form masses; finally masses would accumulate to form worlds and solar systems. As a crowning event when the temperature became sufficiently low, life, both vegetable and animal, would have its origin and be gradually evolved. This would be evolution from the electron or corpuscle to the highest forms of life. Such an evolution our own solar system has not unlikely experienced.

On the other hand if our earth and all the bodies of the solar system should increase in temperature progressively and sufficiently, this order would be reversed and our solar system would be reduced to a chaos of corpuscles. This would be devolution.

Among the heavenly bodies and systems we find evidence of both processes. Some worlds seem to be in the process of formation, others in the process of disintegration. Among some we find apparently unmistakable evidence of elements disintegrating into simpler constituents, among others evidence of elements being formed from simpler constituents. Thus, throughout the universe we have evidence of the evolution and devolution of matter; evidence seemingly indicating that elements and worlds are being evolved in some systems, and devolved in others.

The age, source of heat, and future duration of the sun, and of our earth have always been much mooted questions. If the sun were being consumed by the hottest reactions known to chemistry, and had the same specific heat as has water (the highest known), the temperature of the sun would decrease 2 degrees C. or 3.6 degrees F., every year. As the temperature of the outer portions of the sun is 6,000 degrees to 7,000 degrees C., it would have cooled completely during historic times. Its future duration as a source of heat and all life on the earth would thus be limited to a few centuries. The past duration of the sun and earth must be measured in hundreds of millions of years as the smallest unit. Scientists have long known that the sun must possess some unknown source of heat. Radium suggests such a source. In the atmosphere of the sun there is a considerable quantity of helium. In the atmosphere of the earth we find a very small amount. On the earth the only known source of helium is radium, and the other radio-active elements. It seems likely, therefore, that the sun contains a considerable proportion of radium or of other radio-active elements. Perhaps conditions in the sun are such as to make many elements radio-active which are not appreciably so on the earth. Thus much heat may be liberated by atomic disintegration. The presence of one five-thousandth of a per cent. of radium in the sun, would balance the heat expenditure for all future ages. Rutherford cal-

culating the amount of helium in uranium minerals demands 400 million years as the age of the earth. This result is about the same as that obtained by other methods.

The corpuscle or electron has suggested explanations, more or less probable, for many phenomena which have long been regarded as among nature's most perplexing problems. Such problems as comets' tails, sun spots, polar lights, magnetic storms, formation of fogs and clouds, temperature changes, and thus changes of the weather, may here be mentioned. It is possible that mental telepathy, if it exists, may be explained as due to corpuscles emanating from one mind and capable of exciting response in another mind properly adjusted. We must pass over these questions with this brief mention.

As to practical applications of radium a few words may be considered in order. Radium has already found application in surgery, serving as a substitute for the X-rays, and lacking the harmful after-effects of the latter. The sources of radium are so limited that it will probably never receive broad application. Radium, however, has shown us an important principle, the principle of atomic disintegration, and this principle may lead to marvelous results in the future.

"Prof. J. J. Thomson as a result of his calculations concludes that a gram of hydrogen," about 1.29 of an ounce, "has within it energy sufficient to lift a million tons through a height considerably exceeding one hundred yards;" (1) and since the amount of energy is proportional to the weight of the atom, the energy of the other elements, all of which are heavier, such as sulphur, lead, or mercury, must enormously exceed this amount. Prof. Thomson's calculations usually square with fact. "The energy whence we obtain our manufacturing power whether derived from burning coal, or gas, or any other chemical reaction, depends upon the action of one system of atoms upon another. It is absolutely insignificant compared with the energy locked up within the atoms themselves. We know that this energy exists," (1) but it is not within our control. But who would venture to predict that our impotence will last forever? Since man knows that every breath of air he draws contains power enough to supply the industries of the world, he may some day find a means of freeing and harnessing that power. Radio-active elements set free this energy spontaneously, other elements may be made to do it if only we can devise suitable means.

"It has been playfully suggested by Prof. Rutherford that some day it might be possible to construct a detonator which would send a wave of atomic disintegration through the earth and decompose the whole round world into helium, argon, and other gases, leaving literally not one stone upon another. Without being frightened by any such humorous suggestion as this, we can easily grant that with the continuous acceleration of scientific research where one year of the present counts for a

(1) Duncan, page 176.

(2) Duncan, page 177.

cycle of former time, there will come a day in the unending succession of days when men will look with mingled horror and amusement at the burning of coal and wood, and will date the coming in of their kingdom to the time when Curie and Laborde demonstrated the existence and extent of interatomic energy." (1)

(1) Duncan, page 178.

CHAPTER II

MONISM OF PHYSICAL PHENOMENA OF LIFE

Having thus proven probable the origin of all matter from a common source, let us next investigate to what extent the processes of life can be explained as due to the properties of matter as such. In this way we may hope to establish a monism between living and non-living matter and perhaps fulfill Tyndall's prediction that "man will find the potency of all things in matter." Such would be the establishment of Physical Monism. Some one has said, "if it be matter with a soul, we will grow the more reverent."

It has been customary for man in the limited state of his knowledge to assert differences as existent between living and non-living matter which careful investigation has shown do not exist. Man is apt to conceal his ignorance by the use of some term of the meaning of which he has a very vague conception, if any. Thus observing certain differences between living and non-living matter which he cannot explain, he has assumed that living matter is regulated by processes entirely different from those which prevail among non-living material. These processes, man has thought, are beyond human comprehension. Man long thought that he could have no knowledge of them, nor control over them. Such processes were, and are still, to a greater or less extent, called "vital processes."

As scientific research has progressed the supposedly incomprehensible vital processes have one by one proven themselves to be subject to physical laws, to the laws that regulate the interaction of different forms of matter. Although some processes of living matter have not yet been fully explained, we find no evidence of processes in vegetable or animal life which do not conform rigidly to physical laws.

In explaining the so-called "vital processes" in accordance with material laws we will find it convenient to divide the phenomena of living matter into two classes, namely, the purely physical and the mental. Let us consider the various sub-divisions of each of these two classes in the light of modern science. What has science done to explain, or to dispel, the assumption of "vital forces."

If we ignore for the present all mental activities, "the phenomena which enable us to discriminate between dead and living matter are physical processes, e. g. in higher animals the contraction of the heart, the respiratory and other muscular motions." Living machines possess certain functions which machines made by man do not possess, such as automatic development, self preservation, and reproduction. Living organisms also possess a certain definite structure which it is difficult or impossible for man to reproduce by artificial means. "A brain or a kidney

which has been ground to a pulp is no longer able to perform its functions" (1), even though the chemical materials are preserved intact. "Living organisms may be called chemical machines, inasmuch as the energy for their work and functions is derived from chemical processes, and inasmuch as the material from which the living machines are built up must be formed through chemical processes. * * No variables are found in the chemical dynamics of living matters which cannot be found also in the chemistry of inanimate nature." (2).

ORGANIC AND INORGANIC COMPOUNDS.

Let us justify these assertions in detail. Only a few decades ago chemical compounds were divided into two classes, organic and inorganic, ~~compounds~~. These were regarded as distinct and separate. "The products of the organic and inorganic world were considered as remote from each other as are man and the food he eats. Organic compounds it was thought were produced and could be produced only by natural, or "vital" processes of vegetable or animal life. Such compounds as oils, alcohols, and sugars were, it was thought, produced by processes which man could not comprehend or reproduce. Man could analyze these compounds; he could not make or synthesize them.

What was then considered impossible the great French chemist, Berthelot, has accomplished. He produced acetylene by the union of its elements, carbon and hydrogen, in the electric arc. This is evidently anything but a life process. From this as a starting point many other "organic" compounds have been produced. In fact practically all the organic compounds produced by so-called "mysterious vital forces" can now be produced in the laboratory from non-living matter. Plants and animals manufacture their materials strictly in accordance with the laws of matter. We no longer speak of organic as distinct from inorganic chemistry. We prefer to speak of the chemistry of the carbon compounds.

RESPONSE TO STIMULI.

In another department, J. Chunder Bose of India has broken down the distinction between living and non-living matter, namely i their response to physical and chemical stimuli.

If living matter is stimulated, as by mechanical tapping, certain excitatory changes take place expressing themselves as changes of form in muscles, and as electrical changes in other tissues as the nerves and retina. This behavior is called response or irritability. This irritability can be modified temporarily or destroyed permanently by the use of anaesthetics, such as chloroform, or by other poisons. A tissue stimulated continuously and vigorously becomes temporarily less responsive, and recovers full responsiveness only after resting. This is known as the phenomenon of fatigue. Tissue which has been killed passes out of this responsive state.

From a confusion of dead things with inanimate things it has been

(1) Loeb Dynamics, page 29. (2) Same, page 1.

supposed that "inorganic substances," like dead animal tissue must be irresponsive or incapable of being excited by stimuli.

As a result of this assumption the vitalists explained the response of living animals as due to a "super-mechanical" or vital force outside of the laws of mechanics which control inanimate things. This is to establish a dualism between living and lifeless nature. We are interested in establishing a monism or uniformity of laws controlling the two fields. If we can discover responses among the inorganic, or non-living, substances similar to those among animals, the necessity of maintaining dualism will be removed.

Careful experiment has shown that vegetables and metals respond to stimuli just as do animal tissues. The responses can be modified in the same way with all three classes of substances; they can be increased by stimulants, diminished by fatigue, destroyed temporarily by anaesthetics and permanently by poisons. The substances which act as anaesthetics, or as poisons, for animal tissue react in the same way toward plants and metals. In animals response to stimuli becomes feeble at low temperatures and increases up to an optimum temperature of maximum response. Above this temperature the response diminishes. The same is true in every particular for plants and metals.

An artificial eye may be made by beating out a rod of silver into the form of a hollow cup. The inside is made sensitive by exposing for a short time to vapor of bromine. This gives a coating of silver bromide sensitive to light such as we have in the photographic plate. This is comparable to the retina of the eye. This mechanical imitation of the eye shows the same responses to light in the minutest detail as does the natural eye.

We are justified then in concluding that living response is only a repetition of response in inanimate nature. The peculiar behavior which living matter shows in this respect is due to its being matter not to the fact that it is living. In this department material, or physical, monism is firmly established.

PHYSIOLOGICAL PROCESSES.

Anyone familiar with the principles of chemical biology acknowledges the fact that there is no essential difference between the chemistry of living matter and the chemistry of the laboratory. This fact was first essentially established by three epoch-making discoveries.

First in 1780 Lavoisier and Laplace proved that heat in animals is produced by a process of slow combustion. For a given amount of heat a definite amount of oxygen is consumed and of carbon dioxide is produced. The relation between the amount of heat, oxygen, and carbon dioxide is the same for inanimate sources, such as a burning candle, and for living organisms, such as the guinea pig.

Next Woehler succeeded in producing artificially in the laboratory urea, which it was formerly thought could be produced only naturally in the body of animals.

A third step clinched the argument. The oxidation or digestion of foods could be imitated artificially, and the identity of the processes in the body and in the laboratory established. But the artificial processes required a temperature much higher than exists in the body, and much higher than any substance can maintain and still live. In 1836 Berzelius solved the difficulty. He showed that the organs of living bodies contain certain substances called catalyzers or enzymes. These enzymes hasten the process of digestion so that it is accomplished at lower temperatures. Thus the enzymes pepsin and rennin enable the hydrochloric acid of the stomach to digest food more quickly than it could without these enzymes or ferments. Similarly the ptyalin of the saliva renders possible rapid digestion of starch in the mouth; while digestion in the intestines is facilitated by the action of three ferments; amyllopsin for starch, trypsin for albuminous foods, and lipase for fats.

Catalyzers are used extensively in the manufacture of many commercial products, such as sulphuric acid. Our bodies in accordance with their self-preserved functions manufacture their own catalyzers.

The action of the enzymes is chemical. It can be imitated by action of platinum black. The enzymes are soluble substances, which can be extracted from the cell. They can exist and perform their functions apart from the cells which produce them. This is proven by the use of enzymes in artificial digestion.

The chemical nature of the enzymes was first established by Buchner. He took a culture of the yeast cells which produce fermentation of sugar to form alcohol, mixed them with a very fine, hard quartz sand, then subjected the whole to enormous pressure. The sand crushed the yeast cells to a pulp. From this pulp flowed a sap, or liquor, which carefully strained produced exactly the same fermentative action as the yeast cells themselves. Fermentation was thus proven to be a chemical action, and not due to "vital force," as even Pasteur had thought.

The exact chemical nature of the enzymes is unknown. They may be organic peroxides. Several inorganic catalyzers such as platinum black, iridium, osmium and silver resemble the enzymes in action. Substances such as potassium cyanide which destroy action of enzymes, also destroy the action of the inorganic catalyzers.

Thus science has shown that the processes of digestion are explicable in accordance with the same chemical laws which govern matter. In other processes of our bodily organs the same assertion holds. Clotting of the blood is due to a ferment, thrombin. Oxidation processes in the body are facilitated by ferments known as oxidases.

In drowning lack of oxygen produces death in a few moments. Death in this case is due to lack of oxygen which causes the ganglia of respiration to undergo irreversible changes which make revival impossible.

Diabetes is a disease characterized by inability to digest sugar. Extirpation of the pancreas causes the most serious type of this affliction. This fact was long incomprehensible because sugars are decomposed in the mus-

cles. Investigation showed that the pancreas and the muscles each secrete liquids which mixed together act upon the sugar, but separately have no action. Since these liquids contain no cells, the action is strictly chemical.

An overworked heart often suffers fatty degeneration because lack of oxygen causes chemical reduction of sugars and change of sugars to fats.

Many life phenomena can be explained as due to electrical action. When a nerve or muscle is stimulated, the stimulated spot becomes negatively electrified as compared with the neighboring inactive spots. This results in an electrical wave of negative potential being propagated in both directions through the nerve. "This negative wave is propagated with the same velocity as the nerve impulse." It is quite probable, therefore, that the propagation of nerve impulses is due to electrical action. Plants show similar currents.

Waller has determined "the beginning of life in the hen's egg and in seeds of plants by galvanometric tests; he has also determined the cessation of life in the same manner." (1). These facts and many others seem to indicate that all life phenomena are accompanied by electrical phenomena. Let us now investigate the action of salts in the body and see what light they throw on this subject.

It is a more or less familiar fact that absolutely pure distilled water does not conduct electricity appreciably. Dry solid table salt, called by the chemist sodium chloride, does not conduct the electric current. If we dissolve the salt in the water, the current is conducted very readily by the solution. Sodium chloride and other substances which when dissolved in water permit the passage of an electric current through the solution, are called electrolytes. These electrolytes conduct the current because they are divided into two or more parts called positive and negative ions. These bear positive and negative charges of electricity respectively. I review these definitions because of the role ions play in the actions of muscles, nerves, and glands, and to show that we are dealing with electrical phenomena.

Muscles can be made to contract rhythmically by acting on them with solutions of these electrolytes; but not by solutions of substances which do not conduct the electric current, such as cane sugar. These substances are called non-electrolytes. By the use of electrolytes we can vary and control the phenomena of life.

The salts present in the body seem to influence largely "all phenomena which depend on the action of nerves, muscles, or glands." (2). Changes in the proportions of the soda, potash, or lime seem to be especially influential. Sodium chloride of sufficient strength causes muscles to contract rhythmically if sufficient calcium ions also are present. If the calcium ions are too abundant, the contractions cease. Probably all muscular contractions including the heart beat and respiration are due

(1) Loeb: Dynamics, page 70.

(2) Loeb: Dynamics, page 94.

to the substitution of sodium or of potassium ions for calcium or magnesium ions or vice versa. The beat of the heart has been imitated artificially by mechanical means. In the case of certain infectious diseases, the heart may be removed from a human body more than thirty hours after death, and if placed under suitable conditions will renew its life and beat for several hours.

Our skeletal muscles do not contract rhythmically like our heart because of the calcium and magnesium salts in our blood. Presence of these two ions in sufficient amounts prevents contractions, substitution of sodium or potassium ions for these, or vice versa, helps it.

The rhythmical contraction of many forms of sea life such as the medusae, and varieties of the jelly-fish, have also been proven to be due to substitution of ions and chemical action. Such actions are produced in much the same way in the different animals.

Only those substances which form ions produce these effects; in solutions of non-electrolytes, which form no ions, such as glucose, cane sugar, milk sugar, and glycerine, no twitchings of the common muscles can be produced. The evidence argues strongly in favor of ionic action in these phenomena.

The electric "current is an excellent stimulant for the functions of those tissues which may be considered characteristic of animals alone; namely, muscles and nerves." (1). In this respect we see the similarity of action of the electric current on one hand, and the sodium, potassium and calcium ions on the other. "The solid parts of living tissue consist of colloids which are non-conductors, while the liquids are colloidal solutions which contain also salts." (2) The electric current stimulates nerves by producing changes in the concentration of the ions at various places in the nerves. By means of the electric current we can control phenomena of secretion. The action here again seems to be due to the substitution of sodium or potassium ions for calcium ions or vice versa, which causes changes in the physical qualities of the tissues.

The electric current produces effects in the retina similar to those of light. The current passes through the eye "only by means of electrolysis and it may be that the increase in the concentration of ions (wherever their progress is blocked) brings about the light and color sensations caused by the current. It is not impossible that the so-called visual" or "photo-sensitive substances are electrolytes." (3). Pressure or a blow on the eye-ball produces the sensation of a flash. On photographic plates pressure produces changes of the same character as weak light.

The chemical nature of the causes that produce the sensations of smell and taste is well established. The same may be true for the sensations of the skin, and of sensations in general.

(1) and (2) Loeb: Dynamics, page 98.

(3) Loeb. Physiology, page 291.

A few more physiological processes have to be explained in accordance with physical and chemical laws and we will have done with this part of the subject.

The effect of purgatives is explained as due to irritation of the muscles and nerves of the intestines which produces an increase in the peristalsis of the intestines and consequent rush of water into the intestines.

Green plants manufacture food for animals out of the carbon dioxide of the air, and the moisture and electrolytes of the soil; the free oxygen of the atmosphere also is necessary. "The carbon dioxide is utilized for the formation of carbohydrates and probably fats." (1).

Probably every organism produces enough acids to destroy itself were not these acids constantly neutralized. This neutralization is accomplished partly by the carbonates, and partly by the proteids of the blood.

It is a chemical law that the velocity of a reaction increases to two or more times its original amount for each 10 degrees C. rise in temperature. This is approximately true also in living organisms. In the ventricle of the tortoise heart the number of beats is about doubled for each rise of 10 degrees C. between 5 degrees and 30 degrees C. The rhythmical contractions of the jelly-fish, of the heart, and perhaps of such forms in general, are a function of the action of enzymes. This being true we would expect the rate of the heart beat to vary with the temperature as shown, for the action of enzymes is chemical.

Iodine is more soluble in ether than in water. If a small amount of iodine be dissolved in water, then ether added and shaken, the greater part of the iodine will leave the water to dissolve in the ether. Not all the iodine will be absorbed by the ether, the water and ether dividing the iodine proportionately to the solubility of iodine in the two liquids. This illustrates the principle of "coefficient of partition." This coefficient sometimes varies with the temperature. This is true of the coefficient of partition of chloralhydrate between oil and water. The coefficient decreases with fall of temperature, so that as the temperature falls more chloralhydrate will leave the nervous elements which are rich in fat to go to the watery liquids of the body. In consequence of this fact a frog which is poisoned with chloralhydrate at room temperature may become normal again upon cooling, as chloralhydrate must in this case go from the nervous elements into the watery liquids of the body where they do not poison the animal.

CHEMISTRY OF MEDICINE.

The cure of diseases in the body affords many illustrations of chemical action. Almost all the harm done by bacteria is brought about by means of chemical substances which the bacteria produce in their metabolic processes. Many bacteria produce toxins or chemical poisons which cause the diseases. The problem of cure of diseases and of immunity is in many cases a question of introducing into the blood anti-toxins which act on the toxins chemically, neutralizing them and preventing their harm

(1) Loeb: Dynamics, page 71.

to the system. Often bacteria may be present in the system without harm, because anti-toxins are there to neutralize the toxins which they secrete.

In some diseases germs are devoured by the white corpuscles of the blood. This action occurs only after the germs have been acted upon by other substances in the blood. Substances which thus render germs susceptible to the devouring action of the white corpuscles are called Opsonins, from Latin, "opsono," I prepare for the banquet. The ability of the blood to act in this way is called opsonic activity. This activity can be increased by proper treatment. If the germs prevail against the white corpuscles, the corpuscles are destroyed, the germs increase rapidly and the patient dies. It is thus a war to the death between the white corpuscles and the germs, the corpuscles fighting to maintain the patient's life and the germs to destroy it.

The phenomena of internal secretions in our systems afford examples of chemical materials produced by our bodies for their medicinal value. To illustrate this point, we will consider briefly the action of two organs, the suprarenal glands, and the thyroid glands.

The suprarenal glands were at first supposed to have no functions, but to be remnants of organs which had outlived their usefulness much like the vermiform appendix. It was later found that if they are atrophied or attacked by a malignant growth, man is afflicted by Addison's disease. Their removal from animals means inevitable death. These glands secrete a substance, adrenalin, which produces a tonic effect upon the heart, helping it to maintain its pressure; and also exerts a constricting effect upon blood vessels. It is used artificially to prevent bleeding. Adrenalin has proven to be a definite chemical substance which may be extracted from the living organs which produce it, or may be synthesized from non-living materials.

Extirpation of the thyroid glands from the dog is followed usually by the death of the animal in from one to four weeks. Atrophy of the thyroids in young children produces "the condition of arrested growth and deficient mental development" (1) known as cretinism; in the adult the same affliction gives rise to the disease designated as myxodema, "characterized by distressing mental deterioration, an edematous condition of the skin, loss of hair, etc." (2). It was found that these results could be prevented by grafting pieces of the thyroid in the body, or even by injection of thyroid extract under the skin or by feeding the patient thyroid materials. Later a substance, iodothylin, was extracted from the glands. This consists of iodine in combination with protein materials. This is the active material of the glands.

Many more cases of beneficial internal secretions in our bodies might be cited, but these two will suffice to show that our bodies act in many respects like chemical laboratories, manufacturing chemical substances which are necessary for their own preservation.

(1) and (2) W. H. Howell, Physiology, page 795.

REGENERATION.

Regeneration also affords striking examples of chemical action as the controlling factor rather than "vital force." "In many plants and animals when an organ is cut off, a new organ is formed which is identical with the lost organ." (1) This process is known as regeneration. The theory of regeneration has been established by Sachs.

He considers that each organ is determined by a definite chemical substance. Both the quantity and the quality of this substance is decisive in the formation of the organ. "There are as many specific substances in a plant as there are different organs." Thus the formation of flowers and seeds depends upon a storing up of phosphates in the appropriate organs. The flowers and seeds cannot be formed until the phosphates show an excess as compared with the other chemical materials of the plant. An excess of phosphates in a beet may result in the formation of flowers in the first instead of the second year.

Sachs' theory of regeneration is founded on such facts as these. If we cut a piece from the branch of a willow tree, it will, under the proper conditions, form roots near the basal and shoots near the apical end. Sachs explains this in accordance with his above mentioned hypothesis.

According to Duhamel and Sachs there are two currents of sap in the plant, one ascending and carrying stem-forming material, the other descending and carrying root-forming material. When a piece is cut from a plant, the cut surface forms an obstruction where the organ forming materials gather. Experiment has fully confirmed this hypothesis. The leaves act as factories for the manufacture of carbohydrates, and perhaps of all the specific organ-forming materials. These materials dissolve in the sap and flow from the leaves to the base or to the stems. If a piece be cut from the leaf of a begonia, both shoots and roots are formed at the basal end of the leaf to which the substances flow.

Hypertrophia may also be explained on the basis of Sach's hypothesis. If, for example, one kidney is removed, the mass of the other increases. The same seems to be true for other glandular organs. Pathologists explain such phenomena as due to the greater work done by the remaining organ. According to Sachs' hypothesis, if applicable here, certain definite substances cause the growth of the glands. If one is removed the remaining glands are provided with more of the nourishing materials and consequently increase their mass.

Sachs' hypothesis has been confirmed by many interesting experiments which have substituted one organ for another. *Tubularia crocea* of the Pacific Ocean are hydroids which consist of an undivided stem with a polyp at the oral end, and a stolon near the aboral end. When a piece is cut from the stem and placed with its oral end in the sand a polyp instead of a stem grows near the aboral end. If both ends are surrounded with sea water, a polyp is formed at both ends in 90 per cent of the cases.

The role of the central nervous system in regeneration is important.

(1) Loeb: Dynamics, page 199 ff.

When an eye is cut from a crustacean, a new eye may be formed, or an antenna may grow in its place. "If the optic ganglion is left intact a new eye is formed;" (1) but if the optic ganglion is removed an antenna is formed. By transplanting the optic vesicle of frogs a lens can be formed in any part of the body provided only the vesicle is placed in contact with the ectoderm. This may perhaps be explained as due to definite chemical reactions between chemical substances of the optic vesicle and the cells of the ectoderm.

A mammary gland transplanted to the ear of a guinea pig secreted milk normally when the animal bore a litter. Here again it seems reasonable to explain this strange behavior as due to action between the cells of the mammary gland and materials carried in the blood.

Formation of organs involves differentiation of materials. Under some conditions the process reverses, and the organs revert to the undifferentiated state. If fresh water planarians are starved they become gradually smaller in size, and finally return to the embryonic condition. Such phenomena suggest the reversible reactions so prominent in chemistry.

PHOSPHORESCENCE.

Phosphorescence is another chemical phenomenon found in some animals. Certain pelagic copepods exhibit this phenomenon. In these animals it is caused by a greenish yellow secretion. This secretion continues to phosphoresce even after the death of the animal. Phosphorescence is produced by this substance only when it comes in contact with sea water. The phenomenon is probably due to action of the oxygen in the water on the secretion. This would suggest a chemical action very similar to the action of the oxygen of the air on pure phosphorus which causes the familiar phosphorescence. In the animals under discussion the phosphorescence can be produced by subjecting the specimen to the action of heat, pressure, ammonia, alcohol, or glycerine. These act as stimuli by causing a squeezing out of the reactive secretion.

REPRODUCTION.

Inasmuch as we have found so many of the processes prevalent in living organisms explicable on the basis of chemical principles, it remains to investigate to what extent the beginnings of life can be explained on the same materialistic grounds. We will be surprised, perhaps, to learn of the wonderful discoveries that science has made in this department.

If the fertilized eggs of *Fundulus*, a sea animal, are placed immediately after the fertilizing process into a pure solution of sodium chloride, which contains about the same amount of this salt per volume as does sea water, the eggs fail to develop embryos. They begin the process of development but finally die. "If to the sodium chloride solution a small but definite amount of a bivalent metal (with the exception of the most poisonous ones, like Hg.), is added, just as many eggs form embryos as in normal sea water." (2).

(1) Loeb: Dynamics, page 214.

(2) Loeb: Dynamics, page 46.

Mendel's law has thrown much light on phenomena of fertilization. In investigating various forms of peas he showed that "each hybrid contains two kinds of sexual cells, one possessing the determinants for the discriminating fatherly characteristics only, the other for the discriminating motherly characteristics. Both kinds of sexual cells seem to be present in equal numbers in such a hybrid." (1) This theory is atomistic in its character. De Vries and other biologists have done much to build up the physiology of heredity on this basis.

In ordinary sea water it has not been found possible to fertilize the eggs of the sea urchin with the sperm of the star-fish. If, however, enough sodium hydroxide or sodium carbonate is added to the sea water to render it faintly alkaline, the sperm of the star-fish readily fertilizes the eggs of the sea urchin. Several varieties of hybrids have thus been formed. In this same alkaline sea water the sperm of the star-fish fails to fertilize the eggs of its own species.

It has long been generally agreed that the eggs of a hermaphroditic plant can not be fertilized by the pollen of the same individual plant. This has been found to be true also of a hermaphroditic animal, a variety of the ascidians known as *Ciona intestinalis*. It is possible usually to fertilize the eggs with the sperm of another individual, but not with its own sperm. This is true only with some of the eggs. After putting the eggs fertilized with the sperm of the same individual for about ten minutes into a two per cent. solution of sea water more of the eggs show true fertilization than under normal conditions.

We see then that to a large extent among lower animals the process of fertilization can be controlled by physical and chemical treatment. The phenomenon of artificial parthenogenesis furnishes even more startling evidence.

Parthenogenesis means the development of a female egg without fertilization by the male spermatozoon. Some animals, such as the plant lice (aphides), show natural parthenogenesis. In such cases the development of the egg is due to some condition at present unknown. Many eggs which normally develop only when a spermatozoon enters them, exhibit development when subjected artificially to appropriate chemical or physical treatment. Such development is called artificial parthenogenesis.

Thus "under ordinary conditions the egg of a sea urchin of the Pacific coast does not develop unless a spermatozoon enters it, but the fertilizing effect can be imitated in all essential details by putting the egg for a minute into sea water to which a certain amount of a fatty acid, such as formic, acetic, propionic, butyric, or valerianic acid, has been added, and by subsequent exposure of the egg for about half an hour to sea water whose concentration has been raised by adding a certain amount of sodium chloride." Similar results have been obtained in other forms. Larvae under such treatment develop as rapidly and have as great vitality as those naturally fertilized.

(1) Loeb: Dynamics, page 3.

Adding sodium chloride to sea water increases the osmotic pressure. It matters not what is added to the sea water to effect this increase, whether sugar, urea, or salts; if the pressure is raised sufficiently the parthenogenetic development of the sea urchin's egg will occur. The effect, therefore, seems purely physical.

Let us note at this point, however, that all hybrids, and all animals developed by artificial parthenogenesis have been sterile as far as known. It seems that the entrance of the spermatozoon into an egg has two functions. It starts the process of development; and also transmits the paternal qualities to the off-spring, the hereditary effect. This includes the ability to act as father for another generation. The first function, that of development, has been imitated artificially; the second, the hereditary qualities, have not yet been produced artificially.

Attempts have been made to develop the eggs of higher animals, such as the vertebrates, by artificial parthenogenesis. "Bataillon has shown that the unfertilized eggs of the frog and petromyzom can be caused to segment as far as the morula stage by putting them for some time into a salt solution of a certain temperature, whereby they lose water." Complete development has not yet been attained.

Attempts have been made to extract from the spermatozoon a chemical substance which might prove to be the promoter of the development of the fertilized eggs. The results thus far have been essentially negative. It seems probable, however, that fertilization consists essentially "in the starting or acceleration of a chemical reaction which is going on steadily in the egg." (1) It seems "to consist in the elimination or alteration of a chemical condition in the egg." (2).

STUDY OF OLD AGE.

In our brief consideration of alchemy, we have seen that one problem which the alchemist hoped to solve by his discovery of the "unifying, or monistic, principle of nature," was the prevention or cure of all diseases and the postponement or abolition of the pathological features of old age. To accomplish this would be to make old age more enjoyable and to postpone death. Old age is a gradual decline toward death. I wish next to review what science has done to solve this problem.

To state the question in the words of a leading authority, Dr. Loeb: "Sexual maturity is sooner or later followed by death." (3) Is death determined automatically by the processes of development preceding it? "The fact that most higher animals, at least, die by bacterial infection, and that certain plants, e. g. the sequoia, which are more free from bacteria, can reach an almost fabulous age, renders the answer to this question somewhat uncertain or prevents the generalization of an answer. It is not impossible that further experiments on the egg may aid us in solving this problem. In certain forms, e. g., the star-fish, the mature egg, if

(1) Loeb: Dynamics, page 176. (2) Same, page 177.

(3) Loeb: Dynamics, page 4.

not fertilized, dies rapidly, while the fertilized egg continues to live. For this egg the act of impregnation is a live-saving act." (1).

Most of the philosophical systems of the nineteenth century were characterized by melancholy. There were a number of reasons for this, some of which will be considered later. I wish now to call attention to the fact that the fear of death and disease have had much to do with this pessimism. Gray's reflection that the "path of glory leads but to the grave," would to many mean that life in general is simply the pathway to death. Cakya-Moumi, the founder of Buddhism, was much impressed with the terrors of disease, and this fear did much to determine the pessimism of his philosophy; the same is true of Tolstoi, Schopenhauer, and Hartman. The inevitability of death has impressed many pessimists with a contempt for life. The doctrine of the immortality of the soul has removed this terror. We find no evidence of pessimism in Christ's teachings.

We note also that pessimism is characteristic mainly of youth. Most, or all, of the pessimistic conceptions of philosophy have been formulated by men under thirty years of age. This is true of Tolstoi, of Buddha, and of Schopenhauer. Many of these pessimists have changed to optimism in their old age. This fact has been illustrated by Tolstoi, who from pessimism in his younger days developed to a healthy optimism in his old age as he solved the problem of man's destiny.

Young folks are apt to be either epicureans or pessimists. Those who are not given to reflection pass much of their time in pursuit of pleasures which bring temporary happiness but do little or nothing, at least directly, to solve life's problems. Those who are given to reflection have not yet discovered man's real destiny, and are often rendered pessimistic by the apparent uncertainty and lack of adjustment of things. "Eat, drink, after death no pleasure," was the motto of German students, greedy for pleasure, and not yet having grasped life's true meaning.

Love of life increases as we grow old. At the age of fifty-three, Sir John Lubbock published a book entitled, "The Pleasures of Life," "which opens with the following sentence: 'Life is a great gift.' His attitude toward life is entirely opposed to that of the pessimists" * * * (2) J. J. Rousseau declared: "Life becomes dearer to us as its joys pass away. The old cling to it more closely than the young." (3).

From remotest ages it has been felt that man's life is too short, and attempts have been made to lengthen it. Old people usually have a very strong desire for life unless it is made a burden by infirmity or disease. To solve the problem effectively science must remove the pathological conditions of old age. To lengthen life without this would be worse than useless.

In the enlightened age in which we live such problems are recognized as the domain of science. This has been accomplished only after a long

(1) Loeb. Dynamics, page 4.

(2) and (3) Metchnikoff, page 117.

struggle. Those who had religious matters in charge used to claim such problems as theirs.

~~It is not sufficient that science should cure disease. It is necessary to explain the destiny of man, and why he must grow old and die when his desire to live is strongest, and when his utility would be greatest if we could free old age from its pathological conditions.~~

"It is quite certain that animals, even those highest in the scale of life, are unconscious of the inevitability of death, and of the ultimate fate of all living things. This knowledge is a human acquisition." (1) In some lower organisms, such as the paramecium, the animals exchange parts of their bodies by a process called conjugation. This process brings about complete rejuvenescence of both. Other low forms become young again if extract of brain or bouillon is added to the medium in which they live. "In animals, the life cycle of which is very definite, the signs of senile degeneration are not visible. Insects in the adult condition, very often live only a short time, and die without displaying the slightest sign of age. In the case of lower vertebrates, old age is little known, and has few signs. On the other hand, mammals and birds display senile atrophy in a marked fashion." (2)

"We are so accustomed to look upon death as something natural and inevitable, that it has long since come to be regarded as inherent in organisms. However, when biologists investigated the matter more carefully they failed," in many cases, to "discover any proof of the accepted doctrine." (3) Metchnikoff and Loeb have both reached this conclusion. The world has known no better authorities.

Very low unicellular organisms reproduce by division, thus realizing immortality. There is no evidence of natural death in these animals. Natural death among animals exists, but is very rare. "The best example is that of the curious insects known universally as ephemerids. Swarms of these delicate and graceful insects are to be seen in the summer months around lights. The perfect insects emerge from water, in which the six-legged larvae feed on the organic debris contained in fresh water. The larvae are not predaceous, and escape from their numerous and hungry foes by agility. They are long-lived, some of them passing two or three years in the mud of streams, and in the end become winged insects after a rapid metamorphosis. * * * The flight of the insects lasts only an hour or two, and then in an enfeebled condition, they fall down in vast numbers. * * * The structure of the insect is adapted to this short life. The larvae have powerful jaws, used in the mastication of food, the winged insects possess only vestiges of jaws. They are unable to feed, and so are adapted" only for the briefest existence. Their hour of aerial life is devoted to reproduction. "As soon as they emerge the males and females unite, and the packets of eggs, which are deposited at once, fall into the water, and in a few weeks the young larvae hatch out." (4) This is natural death.

(1) Metchnikoff, page 115. (2) Same, page 232. (3) Same, page 263. (4) Metchnikoff, page 271.

Man probably has a naturally limited life. It is probably about 100 years. Few now attain this age, though we may reasonably hope that the establishment of scientifically proper living conditions may make it quite common. Cases have been cited of very old persons who have felt death desirable, not because of any distress of mind or body, but because of a certain undefinable instinct. Such cases may be regarded as due to a natural instinct for death.

Real old age is a phase of existence in which the natural forces abate never to be renewed. Science knows very little concerning old age and death. Metchnikoff, the famous Russian pathologist, has been investigating the problem. He has arrived at some tentative conclusions which are interesting and more may well be expected in the future. Let us consider what he has discovered concerning the causes and prevention of premature old age and death.

Among the arterial diseases so prevalent in old age some are chronic inflammations due to microbes; others are due to poisons introduced from without as by alcohol and syphilis. Atrophy of the thyroids and other ductless glands brings on symptoms of old age. Persons afflicted with myxodema caused by diseased thyroids, look like very old people. Syphilis brings on symptoms of old age even in a child.

The microbes that inhabit the body are largely responsible for senile decay. This is especially true of those that inhabit the large intestine. These intestinal microbes or their poisons often reach the system generally and produce pathological conditions conducive to old age. An inactive intestine is especially productive of microbe infection. Intestinal putrefaction is obviated by use of milk subjected to lactic fermentation. In souring such milk scientifically prepared ferments should be used. "Rovighi, an Italian physician, drank daily a liter and a half of kephir, a preparation made by subjecting milk to lactic acid and alcoholic fermentations. He found that in a few days the products of intestinal putrefaction in his urine either disappeared or were greatly reduced." (1) "The presence of a number of the lactic acid bacteria is inimical to the growth of the bacteria of putrefaction, and so is of great service to the organism." (2)

A special form of sour milk, "Leben raib," has been used in Egypt from the remotest antiquity. The natives of the Balkan Peninsula, of Algiers, of some parts of Russia, and of Angola in West Africa, use various forms. It has been stated by an eye witness that many of the natives of Angola attain remarkable longevity and display few of the traces of senility. The beneficial effect of the lactic bacteria in sour milk seems to be conclusively established.

Distributed through all parts of our bodies are found certain cells which are capable of independent movements, and perform special functions. These are capable of devouring all sorts of solid matter and have, therefore, been called phagocytes. They devour microbes and other harmful intruders in the body. When in certain pathological conditions clots

(1) and (2) Metchnikoff, page 255.

of blood are formed in our organs the phagocytes devour the blood corpuscles and prevent the harm which the clot would produce if allowed to exist. They thus do very useful work. The phagocytes may be divided into two classes; small active phagocytes usually called microphags, and larger phagocytes called macrophags which may be either active or still. "The microphags rid us of microbes, the macrophags heal mechanical injuries, such as hemorrhages, wounds, etc." In old age the activities of the macrophags are to a large extent harmful.

Senile decay seems to be largely due to a struggle between the higher elements and the phagocytes which results in a weakening of the vitality of the former and an increase in the activity of the latter. Gray hairs are produced by the action of macrophags. The atrophy of the kidneys in old age has been attributed to them. In the brains of old persons and animals the macrophags surround and devour nervous cells, producing decay of the organism.

In view of much evidence Metchnikoff has concluded that senile decay is mainly due to destruction of the higher elements by macrophags. Metchnikoff advocates strengthening of the higher elements, destruction of harmful microbes in the body, and introduction of beneficial microbes, as the lactic bacteria, as means of prolonging life and making old age more pleasant. This can probably be regarded only as a working hypothesis. Nothing very definite seems established on this point.

More than fifty years ago the theory was advanced that sleep is due to autointoxication. It was thought that during our periods of activity, substances are produced in our body which accumulate in the brain and bring on sleep when we are exhausted. These are carried away during repose. Animals which have been compelled to perform fatiguing movements for hours and then killed, have yielded extracts from their muscles which when injected into normal animals produced weariness and even death. Old age may be due to similar processes of autointoxication.

Observance of proper hygienic conditions has done much to increase the length of human life. Increased observance of these laws and of proper living conditions in general, proper diet and perhaps the use of lactic ferments advocated by Metchnikoff, seem to be the only plausible methods of ameliorating old age and prolonging life that science has to offer; but these can do much.

Good actions have been defined as those which make easier the existence of mankind. The scientific study of old age may well be assigned to that class.

We have thus shown the so-called "vital forces" prevalent in living organisms to be in reality physical and chemical processes. We have, however, dealt only with the physical side. We have yet to investigate the mental side of animal activity and see to what extent material laws are accountable for the phenomena there observed. We will approach the subject gradually by considering the phenomena of heredity which partake of both the physical and mental sides.

HEREDITY.

This subject has generally been investigated in connection with the central nervous system. It is of immense importance in educational problems. The form of the body and the instincts we know are inherited. Heredity of instincts can be entirely explained by certain chemical substances present in the egg, as we will soon see. The form of the body can be explained in much the same way. The egg does not contain the form of the full grown animal, but does contain certain chemical substances, especially ferments, which cause the development of this form. "The process of development is a chemical differentiation." When the egg of a sea-urchin was given the form of a double sphere, each sphere developed into a complete sea-urchin. Such a development can readily be understood if we think of it as due to the action of certain ferments on the chemical substances in the egg.

The heredity of mental diseases has often been ascribed to transmission of certain peculiarities of the central nervous system. It seems equally plausible to explain them as due to certain chemical poisons present in the egg and developing in the mature offspring. The delirium of fever and many other mental diseases may originate from poisons present in the body. This explanation of heredity of mental diseases seems more plausible than to think of a defective nervous system as being inherited. These poisons act on the central nervous system and produce the effects of insanity, but they may be formed in any part of the body, not necessarily in the central nervous system. We can probably not, in view of the evidence, deny positively the dependence of these phenomena on the nervous system.

We have seen that the destruction of the thyroid glands retards the mental and physical development of children, often producing idiocy. We have also seen that feeding the patients the thyroid substances of other animals improves or cures them. The action of the thyroid glands is due to a chemical substance. Here then we have unmistakable evidence of insanity as dependent on the presence or absence of chemical action. Other mental diseases may perhaps be explicable in similar ways. Loeb, a leading physiologist of the day, considers that the "office of the central nervous system is extremely doubtful and perhaps disproven." His opinion may be contested by other authorities.

The theory of Mendel and De Vries assumes specific substances as determining hereditary qualities.

CHAPTER III

MATERIALISTIC "PSYCHIC" PHENOMENA

We will next consider some common psychic phenomena and see to what extent they can be explained according to material laws. We are apt in judging such matters to view phenomena from man's own experience. If an animal or an organ acts as a rational man would under similar circumstances, we are apt to declare that the phenomenon in the animal is a conscious one. For this reason many reflexes, especially the instincts, have come to be regarded as mental functions. "A reflex is a reaction caused by an external stimulus and producing a co-ordinated movement, as for example, the closing of the eye. We are apt to ascribe intelligence to such acts because of their purposefulness."

Wherever purpose is apparent we are apt to argue mental control. Consciousness has been ascribed to the spinal cord, because many of its functions show purpose. Plants, however, possess many of these seemingly conscious functions, and we ascribe no consciousness to plants. If we carry the analogy far enough we would ascribe consciousness to atoms and molecules. This would agree well enough with an extremely materialistic view, but is by no means a demonstrated fact. This view is at once exploded when we reflect that the development of the embryo shows a degree of purposefulness that in many cases surpasses that of instincts and many really conscious acts. We do not consider the development of the embryo to be due to consciousness.

"The co-ordinated character of automatic movements has often been explained by a center of co-ordination, which is supposed to keep a kind of police watch on the different elements and see that they move in the right order. Observations in lower animals, however, show that the co-ordination of automatic movements is caused by the fact that that element which beats most quickly forces the others to beat in its own rhythm." (1)

Metaphysicians substitute "a play on words for explanation by means of facts." (2) The scientific method is based always on facts.

Comparative physiology shows that the only essentials for reflexes are irritability and conductivity. These qualities belong to all protoplasm. The reflex acts are determined originally by the irritable structures at the surface of the body and the arrangement of the muscles. The value of the central nervous system in reflexes lies in the fact that the nerves are quicker and more sensitive conductors than is undifferentiated protoplasm. We cannot regard the central nervous system as originating the reflexes and instincts.

(1) Loeb: Physiology, page 10. (2) Same, page 12.

INSTINCTS.

Instincts, at least in their lower, and perhaps also in the highest forms, cannot be regarded as mental acts, though consciousness may, and does in the higher animals, inhibit and control them. Instincts originate largely or totally from chemical or physical stimuli. We cannot regard all instincts as purposeful for they often lead to the animal's destruction. A consideration of some of the common instincts will justify these statements.

SELF-PRESERVATIVE INSTINCTS.

We will start with the instincts upon which the existence of animals depends. I would call these self-preservative instincts, but for the fact that they sometimes lead to the animal's destruction. The flight of the moth into the flame illustrates this. The moth can no more resist the attraction of the flame than can the iron the magnet, even if the moth knows the inevitable result. We know the action of light on the photographic plate. The sense organs of the moth contain material which is stimulated by light; "the stimulus passes to the central nervous system, and from there to the muscles of the wings," and the moth is compelled to fly into the flame. This reflex process agrees in every respect with the effect of light on plants. A plant or animal which is attracted by the light is called positively heliotropic; one that is repelled by the light is called negatively heliotropic. The moth is positively heliotropic. Certain plants when exposed to the light on one side, for instance when cultivated near a window, bend their tips toward the window until the tip of the stem is in the direction of the rays of light. The tip then continues to grow toward the light.

Rhizotrogia, a species of beetle, flies into the flame and perishes as does the moth. But only the male animal exhibits this suicidal instinct. In this case it is known that the animal satisfies its sexual instinct during the night. It seems that the flame excites the animal's sexual organs, and he flies into the flame expecting to find the female there.

A certain worm, *Planaria torva*, always stays in the dark: if brought into light they begin to seek for dark places instantly. The animal has a brain and well developed eyes. If these are destroyed, the animal acts just as before or more slowly. This animal is negatively heliotropic. One experimenter succeeded in making artificially planarians with as many as six heads. In a two headed planarian if the heads were far enough apart, they no longer moved together, but in opposite directions pulling the animal asunder.

A great many sea animals migrate upward in the evening, and descend into lower depths in the morning. These animals never go deeper than 400 meters in their downward migrations. It has been found that at a depth of 400 meters a photographic plate is no longer affected. This fact suggests light as the controlling factor in the migrations of these animals. The movable animals living at the surface of the ocean are all permanently or transitorily positively heliotropic.

One species of animals is positively or negatively heliotropic according to circumstances. Weak light, especially gas light which contains comparatively few of the heliotropically active blue rays, makes them positively heliotropic; in strong light they are negatively heliotropic. Such animals will naturally descend from the surface of the ocean to avoid the strong light; but will ascend in the evening to avoid depths which are too dark. We know the blue rays exert the chemical action on the photographic plate. That is why we illuminate the room with red light for photographic work; the blue rays are also the chemically active rays in phenomena of heliotropism. The assumption of chemical action is thus strengthened.

The behavior of the young caterpillars of many butterflies furnishes evidence of a similar nature. The larvae of *Porthesia chrysorrhoea* creep out of the eggs in the autumn and pass the winter in colonies in a nest on the trees and shrubs. In the spring the warmer sun drives them out of the nest and they crawl upwards to the branches of the tree or shrub where they find their first food. When they have eaten the tender tips, they crawl about until they find new buds or leaves, which in the meantime have developed numerously. This instinct of the caterpillar to crawl upwards as soon as he awakes from his winter sleep evidently saves him from starvation. We are inclined perhaps to say the caterpillar knows where to find the food. Investigation does not bear out this conclusion. The animal is positively heliotropic and crawls upward because the light comes from that direction. The higher temperature of the spring brings about chemical changes in their bodies, and these chemical processes cause them to move in the direction of the light. As soon as they have eaten sufficiently they crawl downwards. Experiments show that this animal is positively heliotropic when hungry, negatively heliotropic when his hunger is satiated.

Here the evidence is conclusive of a self-preservative instinct due simply to positive heliotropism. The central nervous system acts only as a protoplasmic connection between the parts which are co-ordinated for the performance of the reflex. Such functions are performed successfully in plants by undifferentiated protoplasm. To animals it has been customary to ascribe intelligence in the performance of such functions; to plants simply reaction to stimuli. The same forces produce heliotropism in both animals and plants.

Gammarus, an animal, when left to themselves in an aquarium cling to solid bodies in any part of the vessel. If they are transferred to another vessel, or if the water in the vessel in which they are, is stirred, they become temporarily at least, negatively heliotropic, moving away from the light. If certain chemicals are added to the water they become at once intensely positively heliotropic, showing a decided tendency to move toward the light. *Cyclops* is an animal which is normally more or less positively heliotropic. If alkalies are added to the water they become less positively heliotropic, or even negatively heliotropic.

The larvae of *Polygordius* (a marine annelid) are negatively heliotropic

when captured; "in about two hours, they become positively heliotropic." (1) They can be made positively heliotropic without this delay by cooling the water to about 7 degrees C., or lower. If the water is warmed positively heliotropic larvae are made negatively heliotropic.

All these heliotropic reactions in both animals and plants seem to be best explained on the assumption that light has a chemical effect in these cases. The light sets up chemical reactions which cause a contraction or relaxation of protoplasm with a consequent turning of the head of the animal toward or away from the direction of the light. The animal naturally goes in the direction its head is pointed.

Many other apparently self-preservative instincts can be explained similarly. Many worms, insects, etc., have the habit of crawling into cracks and crevices. It has been assumed that the animal does this to escape from its pursuers. The real explanation of the phenomenon lies in the fact that the animal finds it necessary to have all parts of its body in contact with solid objects. Such a tendency is called positive stereotropism. If the animal is placed artificially with its body on all sides in contact with solid objects it remains at rest even if not concealed from its enemies.

In Nereis, a worm, the destruction of the brain does not abolish the burrowing instinct. Experiment has proven it to be a reflex action caused by contact with the ground.

The star-fish if placed on its back soon rights itself, turning over with its ventral side down. This phenomenon has been thought to involve intelligence. It has been shown that contact irritability, or stereotropism, compels the animal to bring its ventral side in contact with solid objects. Intelligence is not the determining factor.

In many plants, even in the dark, the tips of the main roots show a tendency to grow vertically downwards, while the tips of the main stem grow vertically upwards. The tendency to grow downwards is called positive geotropism, the opposite tendency negative geotropism. Animals show similar reactions. The stem of *Antennularia antennina*, a hydroid, grows vertically upward regardless of the position in which the animal is placed.

In crustaceans the eyestalks form a small angle with the horizontal when the animal is in its normal position. If turned on one side, the right eye is raised, the left lowered, thus tending to maintain the normal position in space. In frogs the head tries to keep the normal position relative to the horizon when the animal is placed in an abnormal position. All these stereotropic reactions can be explained as mechanical results of the action of gravity. Investigation does not justify the assumption of intelligence though superficial observation often suggests intelligence.

When certain crustaceans, for instance palaemonetes, are subjected to the action of an electric current, changes take place in the muscles of the appendages of the animal so that the animal shows a tendency to

(1) Loeb: Dynamics, page 133.

move toward the anode rather than the cathode, so that ultimately all the animals collect at the positive pole. This instinct is called galvanotropism. The effect is strictly mechanical, involving apparently no intelligence.

A decapitated frog will brush a drop of acid off its body with its foot the same as a normal frog. This instinct does not seem to necessitate the highest intelligence of the frog located in the brain.

Decapitated bees are still able to walk though awkwardly. If laid on their backs they turn over with the help of their legs. If stimulated on the ventral side they grasp the object with their legs, pull it toward the abdomen and attempt to sting it. If the abdomen is cut from the rest of the body it still bends when irritated on the ventral side, reaches the irritated spot with its sting projecting and ejects poison.

When a dog whose spinal column is divided, thus cutting off the lower part of the body from connection with the brain, is held up by its forelegs, so that the back part of the body hangs down vertically, a strange phenomenon is observed. The hind legs perform pendular motions resembling those used in locomotion. The motions seem to be produced by the stretching of the skin on the ventral side of the hip-joint by the weight of the legs.

Many worms continue to move after being deprived of their head. Such phenomena seem often explicable according to chemical or physical reactions. They can be modified in the case of some marine species by introduction of salts.

If the tail of a decapitated eel be gently rubbed on one side the tail presses itself against the finger, but if touched with a burning match it is turned away. From these and similar observations which are doubtless correct, Pflüger concluded that the spinal column possesses consciousness. The assumption of consciousness is not borne out by investigation. The tail is positively stereotropic, but not positively thermotropic. The burning match causes relaxation of muscles which move the body toward the stimulated side. The stimulated spot consequently moves away from the match. The finger causes tension of these muscles and consequent motion toward the finger. The notion of a spinal-cord soul is thus exploded. The reactions of the eel are due not to consciousness, but to surface structure and irritability.

INSTINCT FOR FOOD.

The instinct for food in some of the lower animals shows lack of intelligence. Prof. Loeb "tied one end of a short thread around a paper wad and the other around a piece of meat, and threw both on the outstretched tentacles of a starved actinian. The tentacles that came in contact with the meat" at once brought "the meat to the mouth while the tentacles that were in contact with the paper did not react." (1) This might seem to argue intelligence, but it has been established that the reaction to food is due to chemical materials diffusing from the meat and

(1) Loeb: Physiology, page 50.

acting upon the tentacles in such a way as to cause a bending of the tentacles toward the mouth. The chemical materials are lacking in paper, hence the animal does not react to it.

Lack of intelligence in this instinct has been proven by experiments on an actinian of the Mediterranean, known as *Cerianthus membranaceus*. In this animal new tentacles have been produced by an artificial incision in the body. In some cases the tentacles were formed without a mouth. These new tentacles react toward food just as do the tentacles near the natural mouth of the animal. If a piece of meat is offered to the artificially produced tentacles they seize the food and press it against the place where the mouth should be. This attempt continues for some time when the tentacles relax exhausted and the meat falls off. This experiment has been repeated again and again with the same animal, and has always been attended with the same result. The animal seems incapable of learning from experience. Its instinct seems altogether blind.

In cases where the artificially produced head was near enough to the natural one the effect was tried of stimulating both sets of tentacles with the same piece of meat. In such cases a fight arose between the two sets of tentacles, and starvation resulted. Experiment further showed that a single tentacle, severed from the animal, grasps a piece of meat and bends in such a way as to press the meat against the place where the mouth of the animal would be. The dependence of this instinct on chemical reactions, and its independence of intelligence as the word is ordinarily used, seems established.

The feeding appendages of *Limulus* show ability to discriminate the chemical and tactile nature of food that is offered to it, just as do the tentacles of the actinian. Unless the offered food fulfills the proper chemical and mechanical conditions they refuse to accept it.

It has been customary to regard the instinct for food and self-preservation as belonging to the cerebral hemispheres among vertebrates at least. This has been disproven in the case of the frog. That animal catches only objects that are in motion. The cerebral hemispheres do not determine the ability of the frog to see. It has been found that the frog who has lost his cerebral hemispheres is still able to see, and to catch and swallow flies. The feeding instinct of the frog is determined by a number of reflexes which continue uninterrupted as long as the medulla oblongata remains intact.

If the abdomen of a bee is cut off while sucking honey the sucking continues as before.

SEXUAL INSTINCT.

The sexual instinct in many animals shows the same apparent dependence on contact irritability as we have found to be instrumental in determining other instincts.

The abdomen of a crustacean, *Gammarus*, can be cut off during the sexual act without causing it to release the female. It has been demonstrated that chemical substances emanating from the female butterfly at-

tract the male butterfly to it. Insects are affected by very weak chemical stimuli. The clasping reflex of the male frog in the sexual act is a reflex of the arm-segments. It is probably determined by sexual materials in the animal, because it disappears in animals castrated before the period of heat. If the head and back part of the body of a male frog is removed during this period and only a piece consisting of the arms and segmental piece of the spinal cord belonging with the arm remains, rubbing the skin on the ventral side of this piece suffices to produce the clasping characteristic of the sexual act. The medulla is the only part of the nervous system necessary for the act.

In some species of animals the female lays her eggs in places where the newly born larvae find just the kind of food they need. The fly lays its eggs on decaying meat, cheese, or other such material, and on these substances the young larvae feed. When pieces of lean meat and of fat from the same animal are laid side by side, the fly always lays its eggs on the lean meat, and never on the fat. The larvae soon die if supplied with fat instead of lean meat as food. The female fly is positively chemo-tropic toward certain substances formed in foods such as decaying meat, cheese, etc., but which are not found in fat. Consequently the female fly is attracted to lean meat rather than to fat. When the fly is seated on the meat or other reactive material, the muscles of the sexual organs become active, and deposit the eggs on the meat. Perhaps also the positive chemotropism is especially strong when the fly is ready to deposit its eggs. It is certain that neither experience nor volition play any role in this instinct. Probably the decaying meat or cheese sends off volatile chemical materials which act on the sense organs of the fly and attract it.

Even among vertebrates we find evidence of chemical materials influencing the maternal instinct. We know how affectionate the female dog is toward her offspring and how jealously she guards them from the encroachment of strangers. This instinct is inherited and there is no doubt that by the act of giving birth and resulting processes in the sexual organs certain changes are effected in the animal which renders these instincts possible. It has been customary to regard this instinct as one of the highest intelligence. Goltz has found that these instincts show full development in a dog whose spinal cord is severed so far up that no stimulus from the uterus can reach the brain. Loeb regards it as probable that pregnancy, birth, and lactation produce certain substances in the animal that change its character, much as do alcohol, or morphine. It is possible that the sympathetic nervous system plays a role in these instincts, but recent experiments have rendered this improbable. It is known certainly that the action of the central nervous system is not necessary.

SOCIAL INSTINCTS.

We will next discuss briefly the co-called social instincts of some animals. "It is a well known fact that if an ant be removed from a nest and afterwards put back it will not be attacked, while almost invariably

an ant belonging to another nest will be attacked. It has been customary to use the words memory, enmity, friendship, in describing this fact." (1) The ant is popularly regarded as a very intelligent animal.

An ant was placed in the liquids, blood and lymph, squeezed out from the bodies of nest companions and was then put back into its nest; it was not attacked. It was then put in the juice taken from the inmates of a "hostile" nest and was at once attacked and killed. Chemical stimuli of certain volatile substances will excite the ants. We need not assume intelligence. The assumption of machine-like irritable structures is quite sufficient here to explain the reaction. Memory is quite unnecessary. The knowing of "friend and foe" among ants is thus reduced to different reactions, depending upon the nature of the chemical stimuli and in no way depending on memory.

Memory and intellect are supposed to be responsible for the fact that an ant is able to find its way back to the nest, and when "foragers" have discovered honey or sugar the other ants of the nest soon go to it in great numbers. The ability to communicate information was assumed. An ant when taking a new direction always returns by the same path. This shows that some trace must be left behind as a guide back to the nest.

If the ant returning by this path bears no spoils no other ants try this direction. But if it brings back honey or sugar, other ants try the same path. Something of the substance carried over this path by the ant is left behind and is strong enough to effect the ants chemically.

Lumbricus foetidus, a worm, when placed in a transparent closed vessel, appears to be positively stereotropic. When they reach an angle of the aquarium they remain crawling along with the glass touching them on two sides. They also remain where the light is weakest and may therefore be regarded as negatively heliotropic. When one animal settles down in a place, the remainder show a tendency to collect there. This has been regarded as an example of sociability among animals. It is probably explicable by the principle of chemotropic irritability. The surface secretions from the animal have a quieting influence on other worms of the same species, with consequent assembling of the animals.

A careful consideration of the instincts thus far described renders plausible the theory that their origin is due to chemical and physical stimuli. We must of course be careful not to infer too much. The experimental evidence as far as conducted is convincing and we may readily formulate a theory which is in accordance with the same. But discovery of additional facts at any time may render necessary a revision of our theory. I think, however, we are safe in saying that the action of the central nervous system and of intelligence is not necessary for such instincts as we have thus far considered. They seem to be most easily explained as due to the chemical and physical nature of the reacting organs and of the materials to which they react. To complete our theory of instincts let us consider some of the more complicated.

(1) Loeb: Physiology, page 220.

Male frogs that have lost their cerebral hemispheres still show sexual instinct but are much more indifferent in the objects which they clasp. The normal frog will clasp only the female frog, the abnormal frog will show the same tendency to react to any object placed in its way. If the skin of a normal frog is touched it may or may not croak. When the cerebral hemispheres have been removed the croaking action never fails. Frogs and pigeons without cerebral hemispheres are capable of spontaneous movements and of vision. They move and avoid objects, but all objects are avoided with equal readiness. Such a pigeon shows sexual desire during the period of heat but will not go to a female pigeon placed in its way. A falcon which has lost the use of these hemispheres jumps upon a mouse and seizes it if it moves where the falcon may see it. But it makes no attempt to devour the mouse as does a normal falcon. A dog under similar treatment shows simple instinctive reactions but lacks those dependent on associative memory.

In the frog the more complicated instincts have been shown for the most part to be a series of segmental reflexes. By use of the principle of transmission, the more complicated instincts in most or perhaps all of the animals can be resolved into similar series of segmental reflexes acting in co-ordination. In this way contact irritability and nervous connections may account for even the highest and most complicated instincts.

It is customary to assign all such functions to the central nervous system and to regard them as involving intelligence. In some animals a high degree of complication is attained in the instincts where no central nervous system exists or where it acts only as a quick and sensitive protoplasmic conductor. Co-ordination is explained by irritability and conductivity in medusae, in the heart, and in the movements of the earthworm and the salamander. The nature of the nervous connection alone determines the co-ordination of different segments in a complicated act. Simple instincts may be determined solely by surface features, the more complicated ones involve connections by nervous elements. If, however, we assume in all cases intelligence and conscious purpose we assume more than the best evidence justifies. This is true even in many of the higher animals, though in them the central nervous system has advantages.

By use of this system less energy and time are required for conducting a stimulus. Muscle fibres are not so irritable as are nerves. In higher animals it is often thought that the higher nervous elements have assumed functions which in lower animals are performed by the surface organs. The best evidence is against this conclusion and favors the same conditions for higher and lower animals. It is often stated that the purposefulness of the instincts in higher animals is due to the central nervous system but plants show reactions equally as purposeful and we find in them nothing of as high an order as the central nervous system.

The accepted principles of evolution explain the apparent prevalence of purpose in the instincts. They state that those animals whose instincts are purposeful and suited to their preservation will survive, while

those whose instincts are conducive to destruction will eventually be exterminated. The existence of the instinct may be accidental. Thus the instinct of the moth to fly into the flame will exterminate it unless the fecundity of the animal is sufficient to offset this suicidal tendency. The instinct of the fly to lay its eggs on lean meat tends toward the perpetuation of the species.

Instincts seem to depend on machine-like processes. The analysis of many instincts is rendered difficult because changes in the blood may change the irritability and reaction of the animal. Thus the young caterpillar of *Porthesia* is positively heliotropic only while hungry. Its positive heliotropism disappears as soon as it is fed.

ASSOCIATIVE MEMORY.

In higher animals the action of the associative memory becomes a powerful, and in many cases the most powerful, factor. The depth migrations of marine animals can be explained as a simple reaction to light. The migration of birds and the acts of carrier pigeons are complicated apparently by memory. In man the control of the instincts by associative memory and intelligence is especially evident. If then we are to continue our explanation of the phenomena of life as due to machine-like processes, we must turn our attention to an analysis of associative memory.

By associative memory we mean the two following peculiarities of the central nervous system: "First, that processes which occur there leave an impression or trace by which they can be reproduced even under different circumstances than those under which they originated. This peculiarity can be imitated by machines like the phonograph. Of course, we have no right to assume that the traces of processes in the central nervous system are analogous to those in the phonograph. The second peculiarity is, that two processes which occur simultaneously or in quick succession will leave traces which fuse together so that if later one of the processes is repeated, the other will necessarily be repeated also. The odour of a rose will at the same time reproduce its visual image in our memory, or, even more than that, it will reproduce the recollection of scenes or persons who were present when the same odour made its first impression on us." (1) Used in this way consciousness and associative memory are synonymous, for all consciousness involves associative memory. A loss or interruption of consciousness means a loss or interruption of associative memory. To solve the problem of consciousness, therefore, we will investigate associative memory. Intelligence is a more complicated problem. The caterpillar has associative memory but possesses little intelligence.

We find no evidence of the metaphysical idea that all matter, and therefore the whole animal world, possesses intelligence. Only certain species of animals are gifted with associative memory, and have consciousness in the higher forms if at all. Most or all mammals possess associative memory. In these animals the faculty appears only after they have

(1) Leb: Physiology, page 213.

reached a certain stage in their ontogenetic development. This is evident from the fact that associative memory depends upon mechanical arrangements which are not found in all animals, and which appear only after a certain development has been reached. We find in the development of the embryo that certain functions of the animal originate abruptly. The heart beat, for example, starts abruptly only after a certain definite development has been reached. A five-eighths normal solution of sodium chloride is extremely poisonous to the eggs of *Fundulus* during the first twelve hours of their development. After that it is very much less harmful. At that point abrupt changes in the embryo take place. The development of the embryo is a successive development of functions which do not exist in the undeveloped egg.

In those animals which possess associative memory the instincts are extensively modified, and often totally suppressed. Man's experience and memory teaches him the proper use of his instincts. The importance of a proper control of the instincts as dependent on memory is one of the noblest problems of education. The greatest happiness in life can be obtained only if the instincts are subservient to the highest intelligence and will. The will is a function of associative memory; so the training of one involves the other.

Philosophers, criminologists, and philanthropists have often supposed that only need compels man to work. It has been proven that work is an instinct. An individual can determine his destiny in life by a proper control of the instincts.

Since then consciousness, associative memory, the instincts, and will are so intimately dependent upon one another, the unravelling of the mechanism of associative memory may be regarded as the great problem of brain physiology and psychology. Probably the full solution of this problem will be accomplished by physical chemistry.

Let us see what has been thus far ascertained as to the mechanics of this faculty. According to Loeb "the only specific function of the brain or certain parts of it, which we have been able to find is the activity of associative memory." (1) It seems certain that it is located in vertebrates, at least, in the brain proper. We may perhaps regard consciousness and associative memory as the function of a definite machine or mechanism. It has one essential feature in common with the phonograph, it reproduces impressions in the exact order in which they are received.

H. Meyer and Overton have shown that substances which dissolve fats easily are for the most part strong anaesthetics, such as ether and chloroform, and that the ganglionic cells of the central nervous system are especially rich in lipoids, or fatty materials. It is possible that the mechanics of associative memory depend largely upon the properties and activities of the fatty materials present in the cerebral hemispheres.

When a lack of oxygen occurs associative memory first disappears. It has been shown that a reduction of oxygen leads to a liquefaction of the

(1) Loeb: Physiology, page 289.

cell walls in many forms. It is possible that memory and consciousness depend on physical changes in the brain which the liquefaction of the cell-walls prevents. We have, however, very little definite knowledge of the mechanism which controls associative memory and consciousness.

HIGHER FACULTIES.

In dealing with the various so-called faculties the problem becomes more vague. Attempts have been made along the lines of psychic localisation. If this theory were correct we would expect that an animal who has lost the occipital and temporal regions of his brain would be blind and deaf, but would remain normal in other respects. A dog so treated becomes hopelessly idiotic. The processes of association even of the senses are abnormal. This agrees with the idea that the cerebral hemispheres act as a whole and not as a mosaic of independent parts.

The phenomenon of "specific energy of the sense-organs" is of importance in a consideration of the mechanics of conscious processes. By this we refer to the fact that every living organ, such as the eye and the ear, can convert energy in only one definite form; that is, they are special machines. Thus, whether a blow, an electric current, or ether vibrations of about 0.0004 to 0.0008 ^{mμ}mm wave length stimulate the retina, the sensation is always the same, namely light. A blow or an electric current acting upon the ear produces sound. The determination of how this transformation occurs in the various organs would explain the mechanics of sensations and perhaps other phenomena. "The will or the process of innervation for a motion is of the same character as the process of space-sensations." (1) Loeb believes that intelligence depends largely upon the development of the "power of resonance of the mechanism of associative memory." He compares the process to the blending of several simultaneous simple sounds to produce one compound sound.

Thus, though the instincts may be explained largely or totally as due to reactions between forms of matter, too little is known of the mechanism of the higher psychical processes to enable us to extend the same materialistic explanation to them. We must not of course set an arbitrary limit to the possibilities of materialism in these matters. We must not say that these problems are certainly transcendental and beyond man's ken though we may think that many of them are. The progress of experimental science will probably reveal the dependence of many of these phenomena on machine-like processes. We must wait for results. We must not infer too far beyond demonstrated facts.

It is of course permissible, and in fact necessary, to resort to theories to correlate the facts of science and to serve as guides for future investigation. If, however, we fail to distinguish between fact and hypothesis, we depart from the scientific method and are liable to err grossly in our conclusions.

(1) Loeb: Physiology, page 302.

CHAPTER IV

FUNDAMENTAL ENTITIES AND CREATION

SUMMARY.

To summarize briefly the evidence thus far cited, we have found that the origin of all matter from a common material is probable; that many of the apparent distinctions between living organisms and non-living matter do not exist; that by the physical and chemical properties of matter we can explain entirely or in part such physiological processes as digestion, the action of the heart, muscles and nerves, the sensations, the cure and prevention of diseases in the body, including the action of internal secretions, regeneration, and phosphorescence; that fertilization of the female egg in many low forms of life can be accomplished artificially by physical and chemical means; that a scientific study of the material conditions underlying old age and death gives good promise of prolonging and ameliorating human life; that the transmission of chemical ferments offers a plausible explanation of heredity and insanity; that a large number of the animal instincts are due to physical and chemical stimuli acting on matter; and finally that the physical mechanism upon which associative memory and consciousness depend, exhibit definite chemical properties.

All that we have considered up to this point is experimentally established scientific fact with little or no inference. If we attempt to predict what science will ultimately explain on materialistic grounds we may easily err. As far as we have gone physical monism is well established. This system correlates and explains satisfactorily the mysteries of material existence and the material conditions which constitute the necessary foundation of life as we know it. But when we have explained the material basis of life, have we accounted for the origin of life. If we infer that the latter follows from the former we commit the error of assuming that concomitance proves cause and result. The fact that life as we know it exists only in connection with certain material conditions, does not prove that those conditions produced the life, or that the life can have no existence apart from the matter which constitutes the body.

SCIENCE AND THEOLOGY.

"Most of the philosophical systems of the nineteenth century were steeped in melancholy and led straight to a denial of the possibility of happiness and even an advocacy of extinction." Science after its long period of repression and after the persecution of some of the noblest intellects of history, had at last gained dominion over those activities which are her just due; reason had triumphed over tradition and intolerance of honest thought. "Not a single scientist appeared from the third to the sixteenth century who dared to make independent research into man's vi-

tal action, and transcend the limits of the Galenic system." "The chief religious and many systems of philosophy had been long established before the spirit of skepticism dared to inquire whether or no these products of the human mind were really in harmony with fact. Skepticism gained ground little by little, and open war was declared between religious dogmas and authority on one side, and scientific reason on the other." (1)

When science came to her own what was the result? The result was what we must almost inevitably expect when a race or an individual finds that his reason has been stifled, that attempts to learn the truth have been suppressed. The thinking men of the age and their followers finding a few facts contrary to tradition were inclined to throw over all the existing systems of philosophy and theology. Some sought new systems, others claimed none could be found.

We are passing out of that crisis; we abhor the chaos which it produced. We must, however, recognize it as the natural result of conditions and strive to avoid similar conditions at present and in the future. We need not be afraid of the truth. What one age has considered as destructive of essential beliefs, the next age has taken as a matter of course, and adjusted its essential beliefs accordingly. Our theology has experienced an evolution similar to that of all man's other activities. ~~in determining our attitude let us remember, that the only sin is intolerance.~~ "Generally, when a theory is false, a new set of facts overthrows it." (2) That is the advantage of the scientific method as opposed to the authority of tradition.

There never has been a conflict between science and anything essential in religion. Conflicts between natural science and theology have occurred as are almost bound to occur between systems of thought developed independently. Natural science progresses so rapidly that theology has found frequent readjustments necessary to harmonize the two systems. The harmony has always been accomplished and always will, though apparently irreconcilable crises have arisen and will probably be witnessed in the future.

What was the cause of the materialism and pessimism of the last century? In addition to the reaction against the suppression of honest thought, we find an overemphasis of the facts which investigation had revealed, men inferred much more than the facts justified. Unlimited materialism was one result of this reaction.

There have been well known thinkers who have disputed the ability of science to deal with the real problems of life. Thus Tolstoi at first reached the conclusion that life is meaningless because it cannot be harmonized with the fear of death and the prospect of absolute annihilation. He tried to solve the great problem by the facts of science but in vain. His "Return to Faith" was the result. Was Tolstoi's view of the impotence of science justified? Does science inevitably lead to pessimism and

(1) Metchnikoff, page 203.

(2) Metchnikoff, page 45.

materialism? I think we can prove the contrary. Science has solved many problems which were formerly considered beyond her province. Formation of philosophical and theological systems without sufficient knowledge of facts has led to many conflicts when science has revealed the facts. The principles of science are founded on carefully investigated facts, and are, therefore, more reliable. We must wait for results.

MATERIALISM AND YOUTH.

What we have found to be true of pessimism applies equally well to materialism. Most of the materialistic systems have been formulated by young men. Most of these have become idealistic in later years. In their younger days they try, as did the alchemists, to find some simple principle which will unify all the facts of nature; in later years, failing in their attempt, they claim such a principle cannot be found.

This was true of Tolstoi as we have seen; it was true also of Kant and Wundt. Kant in his younger days concludes that the three great mysteries, "God, freedom and immortality," are irreconcilable with "pure reason;" in later years he declares them to be postulates of "practical reason," and therefore indispensable. Kant at first claimed "there can be no science without this mechanism of nature," and that human reason can give a mechanical explanation of all the facts of nature. Later he thought this mechanical explanation was limited. Descartes believed that man's body is merely an intricate machine, but claimed that man has an immortal soul.

HAECKEL.

One noted materialist, Haeckel, has remained so till the last. He summed up the materialism of the end of the nineteenth century in his book entitled, "The Riddle of the Universe." He is one of the leading biologists of the day. His views, therefore, have carried much weight and influenced many readers. His book has been discussed and his extreme materialism and atheism have been shown to lack confirmation from the best evidence of science, by Sir Oliver Lodge in his treatise on "Mind and Matter." To ascertain to what extent science justifies extreme materialism, or physical monism, I will devote the greater part of the remainder of the paper to a consideration of the views of Haeckel and to Lodge's answers to the same. In this way we will balance the authority of one leading man of science against another.

To quote Lodge: "Haeckel would say mind, consciousness, affection, art, poetry, religion and all the other facts of man's experience have no real existence except as a necessary concomitant of a sufficiently complex material aggregate. But he does not demonstrate it." Haeckel "tries by surveying the psychic world, from protist to man, to prove the natural origin of every power and content of the human soul." To upset Haeckel according to Lodge, "it is sufficient to meet him on scientific grounds, and to show that in his effort to simplify and unify he has underestimated some classes of fact and has stretched scientific theory into regions of guess-

work and hypothesis, where it loses touch with real science altogether."

SEVEN WORLD ENIGMAS.

I think we will find that Lodge's statement is justified. Emil du Bois Reymond in his famous "Ignorabimus" speech delivered before the Berlin Academy of Sciences in 1880, "distinguished seven world-enigmas, which he enumerated as follows: (1) The nature of matter and force. (2) The origin of motion. (3) The origin of life. (4) The (apparently pre-ordained) orderly arrangement of nature. (5) The origin of simple sensations and consciousness. (6) Rational thought, and the origin of the cognate faculty, speech. (7) The question of the freedom of the will." (1) Haeckel deals with these seven problems and seeks to find their answer in the properties of matter. The nature of matter, origin of motion, and the origin of simple sensations and consciousness, Du Bois Reymond states are "entirely transcendental and insoluble;" Haeckel seeks to solve them by his conception of substance: the origin of life, the orderly arrangement of nature, and the origin of rational thought and speech, Du Bois Reymond considers "capable of solution, though extremely difficult;" Haeckel regards evolution as their solution: as to the freedom of the will Du Bois Reymond remains undecided; Haeckel asserts that it has no existence.

MATTER AND FORCE.

Let us consider these seven problems in detail. First the nature of matter and force. In dealing with this problem Haeckel brings forth his "law of substance," and asserts that it is the "only cosmological law," (2) and "that all other known laws of nature are subordinate to it." (3) Under this "law of substance he includes two well established laws of science, the law of the "conservation of matter," and the law of the "conservation of energy." These laws state that matter and energy cannot be created or destroyed. What Haeckel calls the "law of substance," Lodge designates as the "persistence of the really existent." Persistence is the criterion of real existence." Matter and energy cannot be thought of as either going out of existence or as coming into existence at any time. We seem here to be dealing with the mysteries of the creation. Even if we accept Haeckel's view that substance underlies all the phenomena of nature, how can man explain the origin of substance and the origin of the properties of substance. At present we must regard this problem as unanswered by science. Most thinkers regard matter and energy as two distinct entities, Haeckel classes these two as one. At present many scientists regard ether and motion as the two fundamental physical entities. The "pristine ether" may be the material substratum from which all forms of matter are evolved.

Du Bois Reymond's "second world enigma" "the origin of motion," Haeckel regards as an "innate and original property of substance." If we grant this, how can we account for this property except by creation. The ultimate origin of things seems beyond man's ken.

(1) Haeckel, page 15. (2) and (3) same, page 211.

"There is," according to Lodge, "no serious scientific demur to Hæckel's assumption of a monism of the physical world, and his identification of vital force with ordinary physical and chemical forces." (1) Had Hæckel stopped at this point his system might stand unchallenged. But proceeding from this well established doctrine he draws inferences which are largely unsubstantiated or refuted by science.

LIFE.

The origin of life was regarded by Du Bois Reymond "as capable of solution, though extremely difficult." "The nature of life is unknown; no relation has been established between life and energy, or between life and ether." (2) Hæckel regards life as a by-product of matter, but all he does to explain the relation is to assume that matter possesses the attribute of life. It is an error to assert that the properties of a whole must essentially belong to its parts. An accumulation of atoms and finally of stones may make possible the existence of an atmosphere where none existed before. This atmosphere makes a whole new range of possibilities; but we must not conclude that the atoms or stones necessarily possessed or made the atmosphere or any of the resulting possibilities.

On one point science is definite; that at one time life could not have existed on this planet. It made its appearance at some definite period. Whatever life is, it is something that began to interact with the matter of our globe at some time unknown to man, when certain material conditions were attained on the earth. These conditions may be definite though unknown. But granting all this we cannot say that life "is a function of matter, any more than that the wind is a function of the leaves which dance under its influence; there is nothing in it even to contradict the notion that it sprang into existence suddenly at a literal word of command."

Lodge uses a very instructive analogy to illustrate this point. It was at one time thought that magnetism could be developed only in iron. It was, therefore, regarded as a property inherent in iron molecules, but exhibiting itself only under special conditions. It is now known that a conductor carrying an electric current is surrounded by a magnetic field where no iron exists. Science has not accounted for this fact: if, however, any one should assert that magnetism exists everywhere in the ether but attaches itself to matter only under special conditions, he would make a statement which no one could conclusively reject, and which many accept. Magnetism does exist apart from iron, perhaps apart from matter; similarly life may exist both before and after its connection with material bodies. This theory, however, does not explain the existence of the individual life. Science offers no explanation on this point so far as I know. This is one unquestionable fact for which science offers no explanation.

Lodge offers a plausible explanation of how matter may suddenly become the vehicle of life where no life existed before. I will outline his theory briefly. Residual affinity is a corollary of the electrical theory of

(1) Lodge, page 115.

(2) Lodge, page 32.

chemical affinity. Under special conditions simple molecules may unite to give more complex molecules. Water molecules thus unite with many other molecules. Carbon absorbs hundreds of times its own volume of many gases. Aggregates of molecules might possess many properties not exhibited by the simple molecules. Thus protoplasm may be regarded as such a complex aggregate held together loosely by unstable links and capable of re-arrangement under various special conditions. Such an aggregate possesses the properties necessary to constitute it a basis of life; how that life originated is a different question.

The nature of life is still a mystery. We know its manifestations and its material conditions. Of its origin science offers no adequate explanation. We can explain the origin of chemical compounds, but their combination into protoplasm, the physical basis of life, still defies scientific analysis. Life is not a form of energy nor a function of matter or energy as Haeckel has stated. Haeckel is too dogmatic on questions concerning which little or nothing is known. We cannot assign it to any known physical category. Life acts upon matter in accordance with physical laws and does not violate these laws, so far as man has been able to discover. But we must not assume that we know all the physical laws; many may be discovered in the future. "The laws of physics are accurate but incomplete. In life we find no conservation as in matter and energy. A single acorn contains the potentiality of a forest of oak trees, to the thousandth generation, and indeed of oak trees without end." In matter and energy science recognizes perpetuality. If life is a function of matter or energy as Haeckel asserts, must it not be perpetual? If it is not such a function, but is something existing separately, its perpetuality or immortality in some form seems a conclusion difficult to avoid.

Life has never been produced except from antecedent life. I have heard the assertion that science has proved that life can not be produced from matter. This view is false. Science has failed to produce life from matter alone, but that is far different from proving the problem impossible. Failure to prove a point is far different from proving its contrary.

Many biologists regard the artificial production of life as a problem promising probable solution. In our own day unwarranted announcements of the spontaneous generation of life have occasioned no great surprise even in the minds of laymen. Even if life is finally produced spontaneously in matter, that would not prove that it was not previously existent, any more than the production of magnetism near an electric current proves that the magnetism has no previous existence. Life may well have a previous existence, and return to an immortal realm when its earthly career is ended. Science knows no argument to the contrary.

CONSCIOUSNESS.

We turn now to a consideration of the psychic activities, consciousness, sensations, rational thought, and speech. Du Bois Reymond in his "Ignorabimus" speech considers the origin of simple sensations and consciousness to be an insoluble problem; rational thought and the origin of speech

"to be capable of solution, though extremely difficult." Haeckel attempts a materialistic, or monistic, explanation of these. He thinks he finds their solution in physical monism.

In dealing with the instincts we have found that the simplest forms are explained as reactions to physical and chemical stimuli requiring no consciousness. In man and the other higher animals consciousness modifies these instincts. Darwin did much to trace the evolution of instincts from lower to higher forms. Haeckel regards Darwin's work as proving that mental evolution applies to the entire province of psychic life, from the simplest unicellular organism up to man. I think we can safely say that Haeckel overestimates Darwin's evidence.

Haeckel assumes gratuitously that a certain material substance which he calls *psychoplasm* is the basis of all mental processes. Consciousness he thinks is an attribute of all parts, it may be a property of the cell or atom. He gives no evidence to prove this. He concludes that the "psychic phenomena of the protistae form the bridge which unites the chemical processes of inorganic nature with the mental life of the highest animals." (1) Wundt extended "the law of persistence of force for the first time to the psychic world." (2) Haeckel considers consciousness a physiological problem to be solved by a consideration of the laws of physics and chemistry. He states truly that all phenomena of the psychic life are dependent upon certain material changes in the cells of the body. This claim is thoroughly substantiated by experimental evidence, but does not prove that these material changes are the ultimate origin of the psychic phenomena.

SENSATION.

Haeckel makes another gratuitous assumption to the effect that sensation, or conscious sentence, is an "ultimate and irreducible attribute of substance." (3) Weber's law gives to the mechanism of sensations a psycho-physical basis. Neither this law nor any other explains the origin of sensations.

EMOTIONS.

The emotions also Haeckel regards as evolved from matter up to the highest forms in man. "Every shade of inclination, from complete indifference to the fiercest passion," he states, "is exemplified in the chemical relation of the various elements towards each other." He thinks the atom has a rudimentary form of sensation. He asserts that the highest forms of passion in human beings are connected with the most primitive feeling in the lowest animals by a well connected series of gradations.

REASON AND SPEECH.

Romanes has attempted to trace the complete evolution of the highest mental faculties and emotions in man from the simplest sensations and

(1) Haeckel, page 48, quoting Verworm.

(2) Same, page 101.

(3) Lodge, page 112.

instincts of the lower animals. Man and perhaps also some other higher vertebrates reason. Haeckel finds evidence of the complete evolution of all the human faculties in Romanes' work. Even speech, which we regard as one of man's noblest faculties, Haeckel regards as an evolution, for other animals exhibit forms of communication, and more or less definite sounds expressing certain ideas.

In all this theorizing Haeckel has passed far beyond the limits of scientifically demonstrated fact. Even if all he claims should be finally proven, it would not explain the origin of consciousness. Should science ultimately establish simple sensation and consciousness as attributes of the material atom, the origin of these attributes would still be unexplained. Du Bois Reymond's assertion that man cannot explain them might still be true.

We know that a complex piece of matter called the brain, is the organ of mind and consciousness; that its stimulation causes mental activity, that its injury or destruction involves a cessation of mental activity as we know it. It seems true also that each mental act involves oxidation of a portion of the brain substance. But all this does not prove that mind, intelligence, and consciousness have no existence apart from their material foundations.

WILL AND PURPOSE.

When we turn to the question of the "freedom of the will," and "the (apparently pre-ordained) orderly arrangement of nature," we find Haeckel attempting the same mechanical explanation. DuBois Reymond considered the second of these capable of solution though extremely difficult; as to the solution of the first he was undecided. Haeckel denies freedom of the will in man; the difference in him as compared with the lower animals is, he claims, simply a question of degree. We find forces of attraction and repulsion in the material realm. Haeckel finds in these forces a mechanical, automatic, control of the will. He considers the will, like every other psychic activity, to be determined by the organization of the individual and by the momentary conditions of his environment. It is all, he thinks, a result of heredity and adaptation according to the laws which govern the statics of emotion.

This denial of the freedom of the will is a familiar doctrine. It rests largely on inference; neither Haeckel nor any one else has established it conclusively. To most men the freedom of the will seems apparent, though incomprehensible. We have seen that Kant denied the freedom of the will in his early writings, but asserted its existence later.

In dealing with the question of an orderly, preordained arrangement in nature we have a concept which finds ready acceptance in the intuitions of most of us. A careful analysis of the question may compel us to modify our views in at least some details. It is still a mooted question whether evolution requires guidance and control. Can the purely physical principle of the survival of the fittest account for our world as it now exists? Or is some higher controlling force necessary? The machines with whose manufacture man is familiar require a guiding intelligence to fit part to part.

Inorganic matter is driven solely by force, and is not influenced by purpose or consideration of the future. An organism which possesses a mind is different. An intelligent animal resents compulsion, and strives to exert intelligent wilful guidance over itself. To all appearances "life is itself a guiding principle." Mind controls matter and energy and brings about results which without this control would not be accomplished. Design and purpose seem to be the essence of mind. Conservation^{of} of force does not disprove guidance; though matter is conserved we cannot say the same of any single property of matter.

"The whole effort of civilization would be futile if we could not guide the powers of nature." "A cathedral is held together by inorganic forces, and it was built in obedience to them, but they do not explain it." It owes its existence to the thought and intelligent guidance of some one.

There may well be a guiding principle and intelligent control present everywhere throughout the universe and exhibiting itself by the accomplishment of material results. We are not justified in concluding that it has no existence except as a property of matter. "How can purpose in the universe be denied when man himself possesses it?" Whence came this purpose? Since man has not always existed, we must look to some higher source. Let us say to the Creator. We must expect the Creator to possess all the faculties, purposes, and emotions of the creature.

Haeckel admits the possibility of beings in the universe higher than man, but finds no revelation possible from them. We have not reached the ultimate solution of this problem in man. We must, it seems, go higher.

THE SOUL.

There is one more question to discuss, and we will have done with Haeckel's system of materialism, or physical monism. Haeckel thinks that the atom has a "soul of the simplest character." (1) He applies his law of substance to this problem also, and asserts that "spiritual forces are not distinct from it." Materialism would regard the human soul as an evolution from the simple soul of the atom. It was at one time thought that the soul exists in the seed. To quote Haeckel, "The complete copulation of the two sexual cell-nuclei marks the precise moment when not only the body, but also the 'soul' of the new stem-cell makes its appearance." The character of each new-born child is determined by the chemical plasmatic constitution of the generative cells." (1) "Man's psychic life runs the same evolution—upward progress, full maturity, and downward degeneration—as every other vital activity in his organization."

Haeckel's views concerning the soul rest on an assumption which science does not substantiate; the assumption that the soul and spiritual forces which characterize man are produced solely by an evolution from similar properties possessed by the atom in a simpler form. Haeckel does not prove his assertion. He simply assumes that the atom possesses rudimentary spiritual forces.

Our mind is accessible to petition, affection, pity, and many other non-

(1) Haeckel, page 138.

physical influences; and in this way we are subject to truly spiritual control. Lodge applies his principle of the persistence of the really existent to the consideration of the soul. The soul, Lodge claims, is immortal if it exists at all; Haeckel admits its existence. Man has not accounted for the origin of the soul nor proven that it can exist only in connection with the body.

We are so apt to limit existence to that portion of the universe of which we are aware. There may be in the universe many forms of matter, force, and spiritual control of which man knows nothing. Without suitable instruments and sense-organs we would not be aware of music; that would not prove that music does not exist. In natural science we choose certain definite conditions and limit our problem to them. In such cases we can determine results accurately. In transcendental problems we cannot correctly do this. We do not know the boundary conditions. Many problems have not yet been solved by science, and never will unless all the conditions are accurately determined. This is difficult, or perhaps, impossible, in transcendental problems. Some things may be unknowable as Spencer has stated. Science has not given a satisfactory explanation of individuality either in material objects, or in living organisms; yet who will deny its existence.

Noted scientists have admitted all the demonstrated claims of materialism, but most of them have not considered it a complete system. The views of some of these scientists have been cited. Sir Isaac Newton was a pronounced believer in God and in spiritual forces, though he considered it the fundamental purpose of science to find a mechanical explanation of everything so far as possible. He furnished many of these explanations himself. Huxley, the great apostle of Darwinian evolution, was an avowed theist. The arguments which lead us to materialism carry us beyond it, if followed logically. We can accept all the established doctrines of science and find no conflict with our religion.

Some day a system of monism may be formulated which will be complete and correlate all the truth of the universe on its physical, mental, and spiritual sides. Such a system has not been devised. Haeckel tried but failed. There is a monism of the forms of matter of nature. There is also a monism of living organisms, both vegetable and animal; there may be also a monism of psychic processes among animals. But when we compare the purely physical with the psychical phenomena we find an apparent dualism. Unlimited materialism is not a system following logically from established facts of science; it is founded on inferences which reach far beyond the demonstrated principles of science. No one has yet extended physical monism, so as to explain satisfactorily all mental and spiritual phenomena. If finally all these psychic activities should prove to be properties of the atom or even smaller divisions of matter, it would not explain their origin nor their future destiny. They might still have their existence in an immortal realm where after this life their activities would reach a much nobler development.

It is difficult to state conclusively what are the fundamental entities. To me they appear to be three, matter and energy, (or perhaps ether and motion), and consciousness. Science has not yet shown any one of these to be derived from another. If this should finally be accomplished, it seems we must always start with something as originally existent. Let us not venture to say what science can or will do. Man's views on that subject will depend upon the age in which he lives. Were I to venture a guess, and may I be spared the presumption of anything more definite, I should say, we may never expect science to solve the mystery of creation. Man may find that much has been evolved which he has previously thought created. Some one has said "man can make, but he cannot create." He can work never ending transformations in matter and energy, and to some extent in consciousness; he has never created any one of these three, nor made one from the other.

The fact of a creation seems a necessary assumption. It is beyond man's ken; it is God's prerogative. The question is not: Was there a creation; but what was created? The assumption of a creation seems almost an axiom in any system of philosophy, theology, or science. Science cannot precede the creation. It is the mission of science to ascertain what was created, and how the present physical and psychical forms were evolved therefrom.

BIBLIOGRAPHY.

- Author. Title of Book and Date of Composition.
- S. Arrhenius: *Worlds in the Making*; 1907.
- J. C. Bose: *Response in the Living and Non-Living*; 1902.
- H. W. Conn: *The Method of Evolution*; 1899.
- R. K. Duncan: *The New Knowledge*; 1905.
- E. Haeckel: *The Riddle of the Universe* (translated by J. McCabe); 1900.
- W. H. Howell: *A Text Book of Physiology*; 1907.
- Sir N. Lockyer: *Inorganic Evolution*; 1900.
- Sir O. Lodge: *Life and Matter*; 1905.
- J. Loeb: *The Dynamics of Living Matter*; 1906.
- J. Loeb: *Physiology of the Brain*; 1900.
- E. Metchnikoff: *The Nature of Man*; 1903.
- E. Metchnikoff: *The Prolongation of Life*; 1907.
- M. M. P. Muir: *The Story of Alchemy*; 1902.
- Carl Snyder: *New Conceptions in Science*; 1903.
- R. J. Strutt: *The Becquerel Rays and the Properties of Radium*; 1906.
- J. J. Thomson: *The Corpuscular Theory of Matter*; 1907.
- Wells: *Chemical Pathology*; 1907.
- White: *A History of the Warfare of Science with Theology in Christendom*; 1895.

